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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION

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NOTES AND COMMENTS.

Atmospheric Conditions and Industrial Efficiency.

It is now universally recognised that the human machine must work under suitable conditions if its efficiency is not to be impaired and its period of usefulness shortened. Moreover, during recent years it has become apparent that at least some of the unrest found amongst certain sections of industrial workers is the direct outcome of working under uncongenial and irksome conditions. Dr. H. M. Vernon, M.A. (recently Investigator for the Health of Munition Workers, Ministry of Munitions), has conducted exhaustive researches into the working conditions under which metallurgical workers labour. Last week Dr. Vernon, in his third lecture of a series arranged by the Royal Institute of Public Health, dealt with the "Influence of Atmospheric Conditions on Industrial Efficiency." He first dealt with the effect of exhaled carbon dioxide in the atmosphere breathed. During the last few years, he said, it had come to be realised that it was not so important to change the air in the workshops as to provide for a fair amount of movement of the air. Moving air, even if it contained a certain amount of exhaled carbon dioxide, was more invigorating than pure stagnant air. The difficulty was, however, to decide the velocity of the air currents, and he exhibited an instrument, which had been invented by Dr. Leonard Hill, for measuring the velocity of air currents. There was a great difference in the temperature and velocity of the air in various workshops. The velocity should depend upon the temperature. There was not much information as to what constituted the best temperature in workshops, but it was generally agreed that it should vary in accordance with the nature of the work. Probably the best temperature for sedentary workers was between 60 and 65 deg. F.

A number of slides were shown depicting the workers engaged in the various processes in a tinplate works, where the employees were subjected to very high temperatures. In this case, ventilators were provided which blew cold air down on to the workers. Figures of output of the workers in five different tinplate works, extending over some six or seven years, showed that in every case the output fell off considerably during the hot summer months. He had averaged the results of all these tinplate works; taking the average output throughout the year as 100, in January the output rose to about 104.4, whilst during the hot months it fell steadily, and reached a minimum of about 94 in August. In the best ventilated works, where fans were provided, the seasonal variation of output was comparatively small, between about 102 and 98. In one works, where there was no ventilation, the output in January was 110, and about 90 in the summer, but if this particular works had installed a really efficient system of ventilation, the production would probably have increased by about 12 per cent. over the whole year, quite apart from the effect upon the health of the workers themselves. In a steelworks where a shop was low and narrow, and there was no good ventilation, the output in the four summer months was 11 per cent. less than in the four winter months, whilst in a similar works where the ventilation was better, the variation was only about half that amount. Experiments carried out by Dr. J. S. Haldane in a Cornish tin mine, where the air was absolutely saturated, had led him to the conclusion that under such conditions hard physical work was well nigh impossible.

Dealing with the frequency of industrial accidents, Dr. Vernon said that over 100,000 were notified to the Chief Inspector of Factories every year, whilst the number of minor and unreported accidents must be ten times that figure. It would be seen, therefore, that a reduction of accident frequency by 5 or 10 per cent. was well worth while. Such a reduction could be effected by more careful attention to atmospheric conditions. When a shop was unduly cold the fingers of the workers became numbed and clumsy, and lost their dexterity, thus causing more accidents. In a particular works where the normal temperature should have been something between 60 and 67 deg. F., he had found this to be the case. Also, accidents increased when the temperature rose above that point. When the temperature was about 77 deg. the accidents were about 26 per cent. more numerous.

Pattern-making and Moulding Malleable Cast-Iron.*

By H. A. Schwartz.

Pattern-making and moulding practice in malleable plants does not differ greatly from that in other branches of the foundry industry. There are, however, certain vital differences between pattern-making and moulding for malleable cast-iron as distinguished from the same operations in the grey iron trade. These differences arise from the metallurgical properties of the two materials.

The two essential distinctions between white and grey iron lie in the melting point and shrinkage of the two metals. Grey iron castings of moderate size are made of metal containing, for example, 3.25 per cent. carbon, 2.00 silicon and 0.50 phosphorus as compared with the composition of white cast iron which approximates 2.50 per cent. carbon, 0.75 silicon and 0.19 phosphorus. The equilibrium diagram for the iron carbon alloy shows that all alloys above 2 per cent. in carbon finish freezing at the same temperature—1,130 deg. C. It shows further that the point where freezing begins varies with the carbon, decreasing nearly uniformly from 1,550 to 1,130 deg. C. as the carbon increases from nothing to 4.3 per cent. Leaving the other elements out of consideration, the white iron should begin to freeze at roughly 1,310 deg. C., and the grey iron at 1,220 deg. C.

According to Gontermann's data, metal of the composition assumed for grey iron should begin to freeze at about 1,200 deg. C. and be completely frozen at 1,140 deg. C., whereas white cast iron should begin to freeze at 1,330 deg. C. and finish the process at 1,170 deg. C.

The data are not exactly in accord with those based on carbon alone, due to minor differences in the observations on which the data were based. The point to be clearly brought out is the higher point of incipient freezing and longer partially frozen range for white cast iron than for grey iron. The presence of phosphorus in larger amount in the latter still further accentuates the difference, although the writer has no available data on the freezing conditions in the system Fe-Si-P-C.

The data given show clearly that white cast iron must be poured at a much higher temperature than grey iron, since the latter will be liquid at a temperature much below that where the former has begun to set. A further corollary of the difference in freezing conditions is that other things being equal there will be more shrinks or porous areas in white than in grey iron castings. This arises from the longer freezing range of the former corresponding to a larger fluid contraction of the still liquid alloy between the time and temperature of incipient and complete solidification. The consequence of this increased fluid contraction is that as the temperature of complete freezing is approached there no longer remains a sufficient volume of liquid to fill the voids in the previously formed solid skeleton. Therefore, in the last freezing areas, voids remain between the dendritic crystals of the first frozen solid.

The shorter the freezing range the less of this contraction that can occur. It has been shown that liquid iron is a solution of cementite in iron, and Wüst and Peterson have demonstrated that all such alloys freeze as cementite and austenite. However, in the temperature interval just under freezing the higher silicon and carbon metals graphitise by the conversion of cementite into iron and carbon. The iron resulting from this reaction occupies almost the same volume as the original cementite. The total volume, therefore, is increased almost by the volume of carbon liberated. As a consequence there is a tendency to expansion at these higher temperatures. A number of observers, especially Turner, have recorded actual increase in linear dimensions while the metal was cooling and therefore contracting, just under the freezing point.

The expansion due to graphitisation is important in two respects. It causes the casting to be only about 1 per cent. smaller in linear dimensions (3 per cent. by volume) than the pattern instead of double these values for white iron, and also tends to fill up in part the voids left by fluid contraction.

* Extracted from the "Iron Trade Review."

The difference in pattern equipment and moulding methods in the malleable as compared with grey iron industries are due to the necessity for providing against the following differences in the properties of the two metals. 1. The higher melting point and lower fluidity of white iron. 2. Its greater tendency to internal shrinkage due to fluid contraction. 3. Its greater shrinkage from pattern size. It will be noticed that the noun "shrinkage" has two distinct but related meanings to foundrymen. One refers to the reduction in the over all dimensions of the casting as compared with the pattern and the other to the production of porosities due to voids left by the contraction of the fluid metal.

A distinction based on the words "solid contraction" and "fluid contraction" seems desirable but has not gained favour among foundrymen. Accordingly one must be constantly on the alert to avoid confusion due to the indiscriminate use of the term "shrinkage."

Speaking first of this property in the sense of solid contraction, the fact that the shrinkage of white iron is about ¼-in. per foot instead of ⅛-in. per foot in grey iron does not cause any difficulty in pattern-making, except that a proper allowance must be made by using a "double" or ¼-in shrink rule in laying out the work in case the casting is to be used hard. This shrink rule is merely a rule graduated in feet and inches and fractions of inches—usually sixteenths—in which the distance marked as one foot is 12.25 in. A casting from this pattern will come from the mould about true to size.

Fig. 1.

Experiment has shown that the solid contraction of white cast iron (metastable carbon iron alloys) is substantially the same irrespective of composition. On annealing the casting expands owing to the fact that temper carbon and ferrite occupy a considerably greater volume than the cementite from which they are formed. The increase in volume and in linear dimensions depends primarily on the original total carbon and to a less degree on the heat treatment by which the graphitisation is attained and possibly on other more obscure circumstances.

The expansion is assumed to be about one-half of the original contraction so that the shrinkage allowance in pattern-making for malleable is the same as in grey iron, the standard or ⅛-in. shrink rule being used. However, this is true only with metal containing about 2.40 per cent. carbon; with higher carbon this allowance will produce castings which are too large. The changes of shape produced by relieving shrinkage strain in irregular castings also introduce variables.

The heavy solid contraction of the white cast iron also impose a number of difficulties which would not be clear to the reader were he to consider the problem altogether from the standpoint of the net shrinkage of the finished product. It has been said that the total contraction of all white cast iron is constant. However, it is at least unusual that all parts of a given casting cool at the same rate.

Consider a casting having the form of a thin disc with a heavy hub at the centre, as shown in Fig. 1. The hub will be hot and possibly almost fluid when the light disk has already set and cooled to nearly room temperature. The contraction of the disc during this cooling has met but little resistance from the hot and plastic centre. However, when the latter begins to cool, its reduction in dimensions will be resisted by its attachment to the solid thin flange. Sometimes this attachment will be so secure as to permanently stretch the pasty mass within. If this cannot

occur the flange may be torn loose from the hub at one or more places or may even be entirely detached.

In the reverse case of a thin plate surrounded by a thick rim, as shown in Fig. 2, the contraction of the rim would be opposed by the previously solidified centre, either crushing the centre or producing a radial tear in the rim. Generally the point of failure is at or near the hottest part of the casting where the strength is the least. Occasionally, no external defect results, due to the welding up of such defects by molten metal from the centre. Then the consequence is a pipe or other void.

The magnitude of the stresses from this source may be enormous, depending only on how rigidly the last cooling portions are held by their solid surroundings. In grey iron the difficulty is less pronounced due to the lower magnitude of the contraction and to the fact that the solid portions can be deformed slightly without breaking, whereas practically no distortion is possible in the hard iron.

The practical application of this reasoning is that, in the design of parts to be made of malleable cast iron great care must be used to avoid such forms and proportions as will rigidly connect parts of widely different cross section. All sections should merge uniformly into each other, avoiding abrupt changes of thickness. Fairly thin ribs intended to rigidly brace heavier sections, spoked wheels with hubs heavier than the rim, and in general any design in which unequal

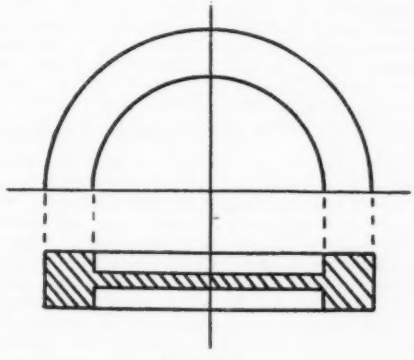

FIG 2.

rates of cooling can set up opposing stresses should be avoided. If such designs are successfully executed by the foundryman it is only by methods of gating or chilling calculated to accelerate the cooling of the heavier sections and retard that of the lighter. This calls for the exercise of great skill and judgment, and may produce prohibitively higher losses with a corresponding increase in cost.

Depending on particular conditions, these shrinks may be widely distributed in insignificant amount at any one place, or they may be concentrated in one spot, aggregating a considerable volume. A casting freezing at a nearly uniform rate throughout, due to equality of section, etc., and freezing almost as rapidly as the iron enters the mould, may have the porosity so uniformly distributed and so nearly filled up from the ladle during pouring as to be practically sound. On the other hand, a casting having a heavy cross section in some one place which is fluid long after pouring ceases, will show a great shrink, especially if the heavy section is high up in the mould.

Two remedies are employed for this trouble. The older is the application of iron chills, which are pieces of cast iron buried in the mould so that they form its inner surface at the points where shrinkage is prevalent. By accelerating freezing they suppress the shrink in their immediate vicinity. However, since the reduction in volume still exists an equal volume of shrinkage will develop elsewhere. This practice is good if the shrink in the new location does no harm, or if in that location it can be suppressed by feeding; otherwise, it is merely camouflage. Continuously supplying molten iron until the entire casting is frozen is the only actual preventive of shrinks.

The shrink always is found in the slowest freezing locality Therefore, if to the pattern there is attached a feeder of still slower cooling rate so located that metal can flow from it to the location in which the shrink was found, then the shrink will be transferred to this feeder and be of no consequence, since the feeder is not a part of the finished product. The actual design of feeders, to meet a given set of conditions may require much skill and experience, but the operating principle is simple.

Feeders are expensive, not only from the moulding viewpoint but also because they involve the melting of much additional iron. Nevertheless, their use is the safest possible foundry practice to ensure sound castings.

The high freezing point of white cast iron necessitates much greater care in gating than is requisite for grey iron. The relatively thin gates commonly used for that metal do not admit of a sufficiently rapid flow to prevent freezing before the mould is filled. Most castings must have metal admitted at a number of points in order to permit the mould to fill sufficiently rapid. Because of the large gates, it is necessary to use special means to exclude slag or sand floating with the current of metal. The thin knife gates of the grey iron industry will choke the stream enough to permit these impurities to rise to the surface and be trapped in the runners. The same principle is used in malleable foundry, but greater care is necessary in making the runners large and providing places for the ascending slag to be trapped on account of the rapid flow of iron required.

Frequently the iron is poured through a strainer core placed at the bottom of the riser, which is intended to cause the latter to remain full of metal and allow the slag to accumulate and float up.

Because of the quick filling of the mould, necessitated by the quick freezing of the iron, great care must be used in selecting moulding sands, and in venting the mould. The air and gas must be able to escape rapidly enough to allow the iron to enter at the rate required to keep it from freezing before the mould is filled.

The selection of moulding and core sands and of core binders, as well as the actual ramming of the sand are further influenced by the high solid contraction of white cast iron. The moulds and cores must be made so as to give readily under the heavy contraction of the casting in freezing. If, for instance, a core be so hard as not to disintegrate before the metal begins to shrink it may set up such a strain in the casting as to actually cause rupture.

In general the steps in the improvement of moulding methods have been as follows:—

Starting with a plain pattern as the simplest equipment, the first step was to attach permanently thereto models or patterns of the gates, feeders, etc., in order that these need not be the subject of separate operations. In the case of small parts this leads to the mounting of several patterns on one gate.

To avoid the labour of producing a parting by hand for each mould, match parts were introduced, which are merely a semi-permanent duplicate of one-half of the mould (generally the cope).

In the interests of greater stability, plate patterns were developed, consisting of fairly thin flat plates, usually of aluminium with the patterns mounted on one or both sides together with the gates, etc. The plate being at least as large as the exterior of the flask separates the cope and drag by its own thickness. Each half of the mould being rammed up off its own side of the plate, the mould when closed corresponds in form to the parts mounted on the plate.

To do away with hand rapping the pattern to withdraw it from the mould, air and electric vibrators often are attached. In some cases, especially for heavy work, the pattern is withdrawn, usually by a lever motion, without rapping, through a stripper plate. The stripper plate is merely a plate representing the parting of the mould having an opening exactly fitting the contour of the pattern at the parting. When drawing the pattern downward through this plate the latter supports the sand and prevents its following the pattern.

Unless the cope and drag are duplicates, two machines are requisite for each job as the construction is evidently such as to be applicable to one-half the mould only for each unit.

XUM

Calculating Charges for Foundry Irons.

Mr. T. A. Dyer, writing in a recent issue of the "Iron Age," deals with the subject of the calculation of cupola charges in a manner readily understood by all foundrymen. He explains that if the chemical analysis of a pig-iron shows that it contains 92.60 units of iron, 3.85 units of carbon, 2.00 units of silicon, 0.05 unit of sulphur, 0.50 unit of phosphorus, and 1.000 unit of manganese, then it is equivalent to stating that 100 pounds of such an iron contains:—

92.60 lb. iron	.. .. ..	92.60 per cent.
3.85 lb. carbon	.. .. ..	3.85 ,,
2.00 lb. silicon	.. ..	2.00 ,,
0.05 lb. sulphur	.. ..	0.05 ,,
0.50 lb. phosphorus	.. ..	0.50 ,,
1.00 lb. manganese	.. ..	1.00 ,,
100.00 lb.	.. .. ..	100.00 ,,

Therefore, in calculating mixtures of metals these points should be borne in mind from the fact that the elemental units in iron are figured on the percentage basis. Thus, if a 3,000-lb. charge of metal consists of pig-iron 1,200 lbs., scrap 1,200 lb. and steel 600 lbs., then the charge percentages will be:—

$\frac{1200\times100}{3000}$ = 40.00 per cent. pig iron.

$\frac{1200\times100}{3000}$ = 40.00 per cent. scrap iron.

$\frac{600\times100}{3000}$ = 20.00 per cent. steel scrap.

100.00 per cent. total charge.

As the iron units are not taken into consideration in figuring analyses, only the carbon, silicon, sulphur, phosphorus and manganese are calculated. The carbon is usually omitted, from the fact that any losses which may occur during remelt will be adjusted by absorption of carbon from the coke bed. The factors which tend to reduce the total carbon in a mixture are low tuyeres and the use of comparatively large quantities of low-carbon material—preferably steel scrap. Suppose the following mixture of metals be used:—

	Si.	S.	P.	Mn.
40 per cent. pig ..	2.00	0.05	0.50	1.00
40 ,, scrap	1.89	0.08	0.70	0.60
20 ,, steel..	0.20	0.06	0.06	0.60
100 per cent.				

Then the following element units, per 100 lbs. of metal, will compose the average mixture:—

$\frac{2.00\times40}{100}$ = 0.80	$\frac{0.50\times40}{100}$ = 0.02
$\frac{1.80\times40}{100}$ = 0.72	$\frac{0.08\times40}{100}$ = 0.032
$\frac{0.20\times20}{100}$ = 0.04	$\frac{0.06\times20}{100}$ = 0.012
1.56 units of Si.	0.06 unit of S.
$\frac{0.50\times40}{100}$ = 0.20	$\frac{1.00\times40}{100}$ = 0.40
$\frac{0.70\times40}{100}$ = 0.28	$\frac{0.60\times40}{100}$ = 0.24
$\frac{0.06\times20}{100}$ = 0.012	$\frac{0.60\times20}{100}$ = 0.12
0.492 unit of P.	0.76 unit of Mn

Two essential points to be borne in mind in calculating and making mixtures are the analysis desired or necessary for a certain kind of casting, and the purchase by analysis of the proper kind of pig-iron to be used as a base or controlling metal in the mixture.

To illustrate the process of working out a mixture, suppose a pipe foundry desires metal of the following analysis:—Silicon 2.25 per cent., sulphur 0.08 per cent., phosphorus 0.85 per cent., and manganese 0.65 per cent. Because of partial oxidation in the cupola, the mixture will require average silicon (2.25 + 0.10) = 2.35 per cent. and average manganese (0.65 + 0.10) = 0.75 per cent. Thus, in a 4,000-lb. metal charge there will be needed:—

$\frac{2.35\times4000}{100}$ = 94.00 lb. Si.

$\frac{0.08\times4000}{100}$ = 3.20 lb. S.

$\frac{0.85\times4000}{100}$ = 34.00 lb. P.

$\frac{0.75\times4000}{100}$ = 30.00 lb. Mn.

Then, assume that the pipe shop has the following materials on hand with which to make the mixture, and it is desired to use 25 per cent. scrap and 40 per cent. "4" foundry iron—what other grade of iron (silicon analysis) will be required to balance the mixture?

	Si.	S.	P.	Mn.
Foundry scrap ..	2.25	0.08	0.85	0.65
"4" foundry iron ..	1.75	0.06	0.85	0.60

Figuring the silicon content, the charges would be apportioned as follows:—

Materials.	Per cent.	Charge, lb.	Silicon, Per cent.	Silicon, lb.
Foundry scrap ..	25	1000 ×	2.25 ÷ 100 =	22.50
"4" foundry iron	40	1600 ×	1.75 ÷ 100 =	28.00
Needed iron ..	35	1400 ×	x ÷ 100 =	43.50
	100	4000		94.00

$x = \frac{43.50\times100}{1400}$ = 3.10 per cent. silicon iron needed.

Other elements, sulphur, phosphorus and manganese, are figured on the same basis; deficiencies or excesses in elements being cared for by the use of desirable pig-irons or alloys, as explained in the following examples:—

Suppose the shop should not have available the necessary "2" soft iron, silicon 3.10 per cent., but had on hand the "4" foundry iron, silicon 1.75 per cent., and the melter desired to purchase a high silicon or silvery iron to use with 25 per cent. scrap and 60 per cent. "4" foundry iron—what percentage of silicon will be necessary to balance the mixture? The assumed charge (designated as "X iron") will be worked out as follows:—

Materials.	Per cent.	Charge, lb.	Silicon, per cent.	Silicon, lb.
Pig, Si. 1.75 ..	60	2400 ×	1.75 ÷ 100 =	42.00
Foundry scrap ..	25	1000 ×	2.25 ÷ 100 =	22.50
X iron	15	600 ×	x ÷ 100 =	29.50
	100	4000		94.00

$x = \frac{29.50\times100}{600}$ = 4.92 per cent. silicon iron needed.

Therefore, it will require a 600-lb. charge of iron with silicon 4.92 per cent. to balance the silicon in the pipe mixture and care for the oxidation loss. Otherwise, 73.6 per cent. (2,935 lbs.) of "4" foundry iron; 25 per cent. (1,000 lbs.) foundry scrap, and 1.4 per cent. (65 lbs.) of 50 per cent. ferro-silicon would answer the purpose.

If a foundry has on hand scrap iron containing 1.80 per cent. silicon, 0.70 per cent. phosphorus, and 0.70 per cent. manganese, and the melter desires to make castings with silicon 2.00 per cent., phosphorus 0.60 per cent., and manganese 0.80 per cent., with the use of 40 per cent. scrap—what pig-iron analysis will be necessary to balance the mixture? The mixture will require an average silicon content of (2.00 + 0.20) = 2.20 per cent.; manganese (0.80 + 0.16) = 0.96 per cent., and phosphorus 0.60 per cent. Assume 2,000-lb. charges are to be used—then there will be required $\left(\frac{2.20\times2,000}{100}\right)$ = 44-lb. silicon; $\left(\frac{0.60\times2,000}{100}\right)$ = 12-lb. phosphorus, and $\left(\frac{0.96\times2,000}{100}\right)$ = 19.20-lb. manganese. The mixture is computed as follows:—

Materials.	Per cent.	Charge, Lb.	Silicon, Per cent.	Silicon, Lb.
Scrap	40	800 ×	1.80 ÷ 100 =	14.40
X iron	60	1200 ×	x ÷ 100 =	29.60
	100	2000		44.00

$x = \frac{29.60\times100}{1200}$ = 2.47 per cent. silicon iron needed.

Materials.	Per cent.	Charge, Lb.	Phosphorus, Per cent.	Phosphorus, Lb.
Scrap	40	800 ×	0.70 ÷ 100 =	5.60
X iron	60	1200 ×	x ÷ 100 =	6·40
	100	2000		12.00

$x = \frac{6.40\times100}{1200}$ = 0.53 per cent. phosphorus iron needed

Materials	Per Cent.	Charge Lb.	Manganese Per cent.	Manganese Lb.
Scrap ..	40	800 ×	0.70 ÷ 100 =	5.60
X iron ..	60	1200 ×	x ÷ 100 =	13.60
	100	2000		19.20

$x = \frac{13.60\times100}{1200}$ = 1.13 per cent. manganese iron needed.

Therefore, it will require 1,200 lbs. for charge of an iron containing silicon 2.47 per cent., phosphorus 0.53 per cent., and manganese 1.13 per cent., to balance the mixture and meet the required specifications.

Probably a more simple method for some foundrymen to figure mixtures would be on the basis of unit percentage of each element in the metal used, instead of total pounds of elements—which would be computed as follows for the mixture given above:—800 lbs. of scrap iron to a total mixture of 2,000 lbs. is (800÷2,000)=0.40 per cent., and 1,200 lbs. of "X iron" to total mixture is (1,200÷2,000)=0.60 per cent.—hence unit percentages of metal mixture are stated as follows:—

	Per cent.	Si.	P	Mn
Scrap iron	0.40	1.80	0.70	0.70
X iron	0.60	2.47	0.53	1.13

Analysis of casting from above mixture will be computed as follows:—

	Silicon	Phosphorus	Manganese
Scrap iron	(1.80 × 0.40) = 0.72	(0.70 × 0.40) = 0.28	(0.70 × 0.40) = 0.28
X iron	(2.47 × 0.60) = 1.48	(0.53 × 0.60) = 0.32	(1.13 × 0.60) = 0.68
	2.20	0.60	0.96
Losses and gains	0.20	0.00	0.16
Metal analysis	2.00	0.60	0.80

Both computing methods produce the same net results; the matter of choice lies with the foundryman to adopt the method which is simplest to his "turn of mind." Computation by both methods will serve as a check on the mixture, and prevent errors.

Varying mixtures may be melted in a cupola during a single heat period by the exercise of certain precautions. To avoid the possible mixing of the separate charges in the hearth of the cupola, it is advisable to separate iron charges by using blank coke charge of about 4 in. in depth. Such practice will hold the upper charge off until the excess coke burns to the melting zone, thus permitting the tapping of the metal in the meantime. By knowing the rate at which the cupola "drives" or works its charges through the melting zone, and timing the operations accordingly, the problem may be solved accurately. The rate at which coke is consumed per minute per sq. ft. of cupola area will solve the problem of burning away the blank coke charge.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Sulphur in Foundry Coke.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have noted with interest the discussion on hard castings recently read before the Lancashire Branch of the Institution of British Foundrymen, reported in your issue of October 27.

Mr. Pell, who opened the discussion, suffered in a measure almost the same trouble as myself at the coal strike period, in the nature of hardness due to sulphur.

However, the figures quoted as being representative of sulphur contents of cokes at that time vary considerably from those received by myself as results of careful and skilled chemical analysis.

I note that he assumes the sulphur percentage as being anything up to 0.1 per cent., which, of course, is mythical, since the very best of cokes under normal conditions are rarely lower in sulphur than 0.45 per cent., usually averaging approximately 0.75 per cent.

Being engaged in the production of light and intricate castings, it was essential to obtain the best possible fuel, and with this in mind any brands of coke were purchased, but before using these a typical analysis was taken for each brand showing determinations for both sulphur and ash, and in this way only the best coke retained for work in the cupola.

The results of some of these analyses, which, as may well be imagined, were numerous, were as tabulated below, and it will be readily recognised that 0.1 per cent. is mythical.

Mr. Pell continues to say that taking the sulphur content at 0.1 per cent., it would give a quantity of 1 lb. of sulphur in a bed charge of 12 cwts.

Sulphur and Ash in the Cokes obtainable during the last Coal Strike.

Brand.	Yorks.	Durham.	Lancs.	Midlands.
	Per cent.	Per cent.	Per cent.	Per cent.
A.—Sul. ..	1.03	1.51	0.84	1.74
Ash ..	11.03	15.50	6.00	14.30
B.—Sul. ..	—	0.91	0.78	—
Ash ..	—	10.60	12.78	—
C.—Sul. ..	—	0.75	1.66	—
Ash ..	—	8.91	—	—

I agree that it would, but since his sulphur content ranged anywhere from 0.70 per cent. up to 1.5 per cent., the quantities of sulphur that would be present in a 12-cwt. (1,344 lbs.) charge would range from 9½ to 20 lbs.

I am not prepared to offer suggestions for overcoming the difficulty of high sulphur coke, the subject having been dealt with very fully by the Institution itself, but since I had these figures beside me I thought they might be of interest to those who were less fortunately placed than myself, allowing them to see for themselves the abnormal conditions under which they were working.

Before leaving the subject, however, I would make reference to one other paragraph in the address, which deals with the clarifying of the coke bed by tapping at short intervals for the first 7 or 8 cwts. of metal down.

This again strikes one as being peculiar since the succeeding intermediate charges of coke, charged to substitute the ash formed in the bed during melting, unless of different and superior brands, must bring with them sulphur to this place, with the net result that for each quantity of sulphur removed from the bed by absorption by the previous iron charge, an almost equal amount is added to the bed ready for absorption by the next iron charge to be melted, allowing, of course, that the amount of sulphur combining with the flux charged is practically constant, and as a practical proof of this I would mention the following experiment.

Having large stocks of inferior cupola coke on hand, reminiscent of the coal strike, I recently endeavoured to rid myself of it by charging the bed charge of good coke of proved excellent quality, the sulphur being only 0.40 per cent., and the intermediate coke charges of this doubtful commodity.

The result of this, as I had half anticipated, was that the iron gradually increased in hardness towards the end of the blow, the same brands of iron and the same quantities of flux being charged throughout.

This was carefully checked by standard mechanical tests made on numbered test pieces taken at various intervals during the blow, which proves that as the good quality coke of the bed was displaced by the poorer quality coke, so the sulphur increased in quantity, and so the iron hardened proportionally.—Yours, etc.,

C. W. KENT,
Assistant Foundry Manager.

16, Beach Grove, Withington, Manchester.

British Brass Industry.

"Modern Developments in the British Brass Industry," by Ernest A. Smith, British Non-Ferrous Metals Research Association, Birmingham, England, was presented before the American Electro-Chemical Society at their autumn meeting in abstract by E. L. Baldwin, General Electric Company, Niagara Falls, N.Y. The author covered electric brass furnaces in England, the extension, hot pressing and forging of brass; rolling mill practice annealing; composition of industrial brasses and treatment and utilisation of scrap brass.

"The Electrician," which first appeared on November 9, 1861, this week celebrates its Diamond Jubilee.

At a general meeting, to be held on November 25, at the Institution of Mechanical Engineers, Storey's Gate, London, S.W., at 7.30 p.m., Mr. A. F. Guyler will lecture on "Drawings and Production."

XUM

Cracks in Aluminium Castings.*

By ROBERT J. ANDERSON, Pittsburgh, Pa.

In sand and die castings of most light aluminium alloys, cracks are due to the large contraction in volume on freezing and to the lack of its regulation or control. The most important factors are: contraction in volume; composition of alloy; quality of melting charge; design of casting; method of moulding; hardness of ramming; method of gating; hardness and characteristics of cores; chills; risers; melting temperatures; furnace used for melting; pouring temperatures; inclusions in alloys; hot shortness of alloys; and physical properties of alloys at high temperatures.

Of these, the first, second, third, and eleventh to sixteenth involve ascertainable metallurgical facts; the remainder are largely matters of opinion, judgment, and technical knowledge of men experienced in the production of castings.

The cracking tendency of certain light aluminium alloys on casting varies with the chemical composition of the alloys. As a general rule, the aluminium-zinc alloys are known to crack more readily than the aluminium-copper alloys, while some aluminium-copper-zinc alloys (such as 85:3:12 Al-Cu-Zn) crack less readily than the former. In general, the contraction in volume of the aluminium-zinc alloys is considerably greater than that of the aluminium-copper alloys; these alloys also are much weaker at high temperatures than the latter. On the other hand, while the contraction in volume of some aluminium-copper-zinc alloys is less than that of some aluminium-copper alloys, the former are much weaker at high temperatures. The strength at high temperatures may be a more important factor than the contraction in volume, at least in the case of some alloys. Heterogeneity, due to segregation, is much more marked in some aluminium alloys than in others; this leads to planes of weakness that may give rise to actual cracks or to strain cracks. While the cracking of steel ingots and castings is somewhat analogous to the cracking of aluminium-alloy castings the contraction in volume of the aluminium alloys is so large that the effect of this factor overshadows the effect of other factors, which are of importance in the case of steel. In the case of aluminium alloys, consideration must be given to any possible contractions or expansions on passing through the solidification range or on cooling in the solid state.

The chemical composition of the alloy and the effect of impurities must be considered. Some claim that the 92:8 Al-Cu and related aluminium-copper alloys are more likely to crack when made up from all-primary materials than when some foundry scrap is used in the charges. In other instances it is claimed that secondary aluminium and secondary aluminium-alloy pigs are likely to give rise to cracks.

Design of Castings.

One of the most important factors that affects the occurrence of cracks in aluminium-alloy castings is the casting design. Thick and thin sections in contiguity form a prolific source of cracks.

The plane of weakness that results from the freezing of metal in the form of columnar crystals at a right angle has been discussed by Desch. Both strain cracks and actual cracks may be associated with the planes of weakness set up by columnar-crystal growth; the latter may be prevented by the use of proper fillets. In moulding, the sand should be sudden collapsing of parts of the mould while wet sand may cause cracks and warping. Ramming, gating, risers, cores, chills, etc., are important in relation to the occurrence of cracks.

Sand moulds for aluminium alloys, if rammed too hard, will prevent the casting from moving while contracting on cooling, thereby setting up strains and at times causing fractures in the casting. If the mould is rammed too lightly, there may be sudden collapsing of parts of the mould while the temperature of the alloy is immediately below that of final freezing.

According to Gillett, one of the principal causes for cracks is the use of cores that are too hard. Cracks will always be less with green-sand cores than with dry-sand, although if higher pouring temperature must accompany the use of green-sand cores, this would tend to increase cracks. The dry-sand core is unyielding as a rule, unless the binder, like resin, will soften readily at the temperature set up on pouring.

Relation of Chills to Cracks.

So far as chills are related to the occurrence of cracks, this defect has been attributed to: lack of chills where chills are necessary; chills placed in the wrong position in the mould or cores; too heavy chills; and too light chills. Where a thin and a thick section are in contiguity, the thin section solidifies first and the thick one later. It may be said, in general, that the failure to chill heavy sections is a usual cause for cracks.

Irrespective of the type of furnace, heating to too high a temperature should be avoided at all times, for metals and alloys dissolve more gases with increasing temperatures. On the basis that the greater part of the dissolved gas is carried in the amorphous cement at the grain boundaries in the solid state, it might be expected that the forcing of gas into the grain boundaries would give rise to strains and weakness at these places, and consequently aggravate the tendency to crack.

Shrinkage a Function of Pouring Temperature.

Cracks in aluminium-alloy castings have been attributed to too high and too low pouring temperatures, but opinion is not uniform as to what should be regarded as the correct pouring temperature for the different commercial alloys. An alloy poured at a high temperature will have a considerably greater total liquid and solidification shrinkage than one poured at a low temperature, since the total shrinkage is a function of the pouring temperature. In general, a high pouring temperature (which presupposes a high melting temperature) may be expected to cause cracking, which would not occur with a lower pouring temperature under otherwise similar conditions. A too low pouring temperature has been claimed to be the cause of cracking, but it is difficult to see how this can be so.

The presence of foreign inclusions in cast aluminium alloys, such as dross particles, so-called "hard-spots," and other included matter, has been associated with cracking. Cracks in both eutectiferous and solid-solution alloys have a strong tendency to be intergranular, and where foreign included matter is located at grain boundaries (or elsewhere), it tends to weaken the alloy and aggravate any condition that may lead to cracks.

Methods for Prevention of Cracks.

While cracks have been found in aluminium-alloy castings quite free from foreign inclusions, they are found more often in unsound and dirty castings. It is not to be expected that cracks, as a defect, will entirely disappear by the observance of the precautions given, but they may be largely eliminated. The contraction of volume is a fixed constant for a given alloy, so alloys that have an excessively large contraction in volume should be avoided for the production of complicated castings or those of intricate design; for instance, large and complicated crankcases. Of course, for some simple castings, alloys with high shrinkage may be employed satisfactorily. The contraction in volume may be controlled, within limits, by the correct use of risers and chills so that a given alloy is not necessarily unsuitable for use in complicated castings simply because it has a high shrinkage. Both the contraction in volume and the physical properties at high temperatures are dependent on the composition of the alloys, and alloys should be chosen, on the basis of adequate test data, that properly fulfil the requirements.

Conclusion.

The melting temperatures should be low; overheating in the furnace should be avoided. Open-flame furnaces should be run with a non-oxidising atmosphere in order to avoid the formation of much aluminium oxide, and consequently occluded dross in the alloy. Skimming should be adequately and carefully done and the melting practice should be conducted as cleanly as possible. Foundry-floor sweepings should not be charged into the furnaces unless sieved, and foreign materials should be kept out of the furnace charges. The pouring temperatures should be as low as is consistent with filling the mould readily with metal; high pouring temperatures should be avoided.

* Abstract of a Paper read before the American Institution of Mining and Metallurgy.

Making Moulding Boxes.—Part II.

By Joseph Horner.

Continued from page 356.

To economise sand, and labour in ramming, many flasks for the larger columns and pipes are made with a cross section having the sides sloping inwards, which reduces the sand space away from the joint faces. Complete patterns must be prepared for moulding these. Another large group has to be made in outlines to accommodate patterns that are curved, or cranked longitudinally. These are made with polygonal outlines, or in many cases in the form of a right angle, or with branched portions, these being common for bends of various degrees of curvature, and for tees. Other boxes have frames with cross sections that change, being tapered lengthwise. Others have enlarged portions for bases of columns, capitals, flanges, etc. Fig. 14 is an example of this kind for a column, with provision for various fittings. It is made with an outer frame, having bars inserted permanently in the enlarged end portions, but those for the long parallel portion are rammed in relays.

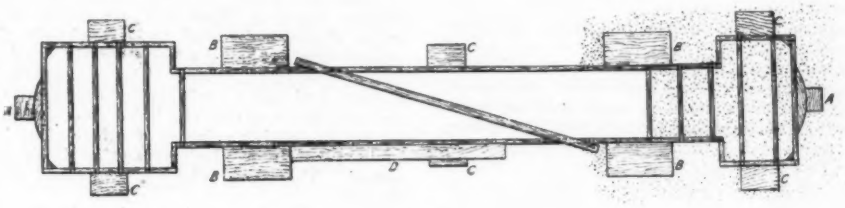

FIG. 14.

In these long boxes it is difficult to prevent distortion during ramming, and to ensure that the two castings for top and bottom shall match exactly. The diagonal strip shown is necessary, but it is also desirable to check the pattern as the ramming proceeds. The ends are liable to become pushed out of square due to the weakness of the construction. Ramming must be done evenly within and without in stages.

The end prints A are for swivels, the prints B are for looped handles, similar to those in Fig. 8 of the previous article, either for turning over or for lowering into a pit. C indicates the covering prints for the lugs. In long boxes used for casting in pits, flanges are cast on the backs to receive back plates, bolted up against them, to prevent risk of a blow-out, due to hydraulic pressure, from occurring. These can be moulded in sectional lengths from a short strip, D, by working it along.

The usual forms of box bars are shown in the group, Fig. 15, A being the plain parallel stay for top boxes, B that fitted in boxes such as Fig. 14, and many others, to embrace work that is circular in cross section. C and D are top stays which fit respectively within and without patterns. In such cases if a box were used having straight parallel bars like A, lifters would have to be hung from the bars to support the deeper-lying sand, E and F are typical of many special forms, made for boxes for repetitive work. Whatever the shapes of bars may be, if they are uniform along the box, it is not necessary to make a pattern for every one, but three or four will suffice. But it sometimes happens when sections change constantly, and pattern outlines are awkward, that the safer way is to lay the box pattern frame over the pattern, and cut every bar to leave the proper clearance of $\frac{3}{4}$ in. or thereabouts.

Circular boxes (Fig. 16) economise sand in making gear wheels, pulleys, trolley wheels and similar objects. Complete patterns are not prepared for these, because the circular portion would have to be built up in segmental fashion, and would be costly. They are made by sweeping the circular portion, and ramming the cross bars within the central space. Two forms of sweeps can be used—one, Fig. 17, attached to a radius bar, and so worked round; the other, a block, Fig. 18, laid on a levelled bed and rammed in successive stages. If the form in Fig. 17 is used, the interior of the box can be rammed at the same time as the exterior, and this must be done in making a middle part without bars, or a bottom box having flat bars. It is not necessary in moulding a cope part with its deep bars. For this, two pattern sweeps are required, laid in at opposite ends of the patterns of the bars, to support the sand in those localities during the ramming of the stay pieces. Fig. 19 shows a portion of a box rammed and a sweep piece *in situ*, with the pattern and print for a swivel, and the print for a lug adjacent, the same details being shown in Figs. 17 and 18. If patterns are required for repetitive work, then special care will be taken in producing a mould by one of the methods described, omitting the lug prints and swivel parts, filing the pattern to mould from, and attaching the lug prints and those for the swivels in wood. The trouble of using sweep pieces is sometimes avoided by moulding the rim from one of the iron rings employed for pulley making, but increasing its thickness with strips of wood laid round outside.

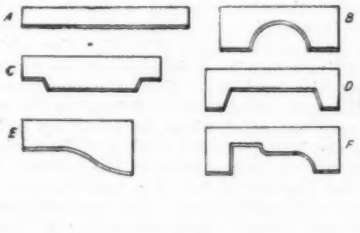

FIG. 15.

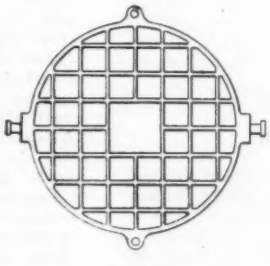

FIG. 16.

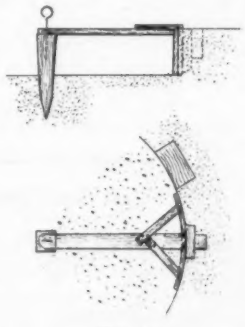

FIG. 17

Box moulds, all above the smaller sizes, are generally poured in open sand. The roughness of the top edges is of no moment, and the bottom or joint edges, which matter, are tolerably true. Fig. 20 illustrates a square box when poured. If of from 8 ft. to 10 ft. square it is poured at four corners, from three ladles—a large ladle supplying the main basin, and two smaller sizes the other basins. The vertical ingates supply horizontal runners that direct the metal into the sides. A

brick is shown laid on each cod of sand between the bars to prevent the metal from dislodging it, this being a precaution in the absence of the pressure of a top part. Four flow-off channels are seen next the corners, cut to the height which

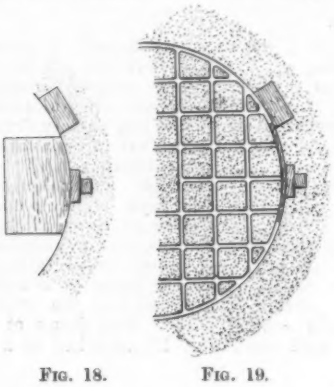

Fig. 18. Fig. 19.

corresponds with the depth required for the casting.

Some boxes—not a large number—have to be cut to curves, or angles in their joint faces, instead of being plane. This is done to avoid making deep sloping sand joints. Such boxes must be made complete, top and bottom matching, and the bars

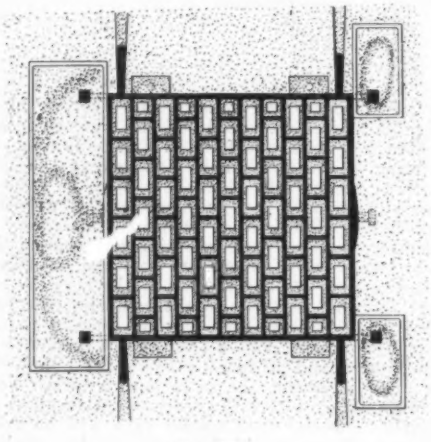

Fig. 20.

must be inserted. Large boxes of common shapes are sometimes made as outer frames only, the bars being cast separately and singly, to be bolted in place. This method is useful where cylinders and crane drums are being constantly made, varying not very greatly in diameters, but having flanges and other attachments which require differences in the bars.

Cast Steel Sheaves.

It may be stated for the information of our readers that His Majesty's Trade Commissioner at Toronto (Mr. F. W. Field) reports that a Canadian firm are in the market for the purchase of four cast-steel sheaves, each 10 ft. in diameter, complete with shafts, sole plates, bearing and pedestals, two of the sheaves to be grooved for ropes of 1⅛ in. diameter and two for ropes of 1½ in. diameter. A blue print showing the type of sheave at present used by the company, but not necessarily the type which will be bought in the present instance, is available for reference at the Department of Overseas Trade, Room 50a, 35, Old Queen Street, London, S.W.1. It will afterwards be forwarded in order of application to those firms in the Provinces who may be unable to arrange for a London representative to view the print. Attached is a statement containing certain details regarding Canadian Customs duties and regulations which may be of service to firms proposing to submit quotations in connection with this inquiry. The name and address of the firm referred to may be obobtained by United Kingdom firms interested on application to the above Department.

Electric Welding of a Cast-Iron Rope-Drive Flywheel.

In a short Paper before the Midland Counties Institution of Engineers, at a meeting held at Nottingham University on Saturday last, Mr. N. E. Webster, O.B.E., described how, owing to a fire that destroyed the power house of the Broughton & Plas Power Coal Company, Limited, which supplied the power for three collieries, including the pumping (which was maintained continuously throughout the 24 hours of the day), the pits were placed in grave danger of flooding. The fire occurred at 1.30 p.m. on April 18, 1921, and was caused through a volunteer workman having dropped a match into the rope-race. Subsequently a preliminary examination showed that all the electrical portions of the three 200-kw. sets contained in the building were ruined, but that of the steam ends of the sets two were repairable. One of these, a Robey compound non-condensing set, with cylinders measuring 15½ and 22½ in., and having a 14-ft. flywheel, rated at 340 b.h.p. and normally driving by means of ten 1¼-in. cotton ropes a 200-kw. Scott & Mountain generator, was tried under steam and found to be workable, the most serious damage being a series of six cracks in the rim of the 14-ft. wheel. The rim weighed about 4¼ tons, and had a peripheral speed of 3,800 f.p.m., the unit stress in the rim being just under 400 lbs. per sq. in., giving a factor of safety of no less than 50 in 1 so far as the rim section itself was concerned. The total weight of the wheel was about 6½ tons.

It was decided to have the wheel electrically welded, provided that the welders would guarantee their work. The first firm who inspected the job declined to do this, however, since the material was cast iron, for which their plant was unsuitable. Another firm of welders was therefore called in, and after an inspection they stated that they were willing to guarantee the success of their method. The first essential in dealing with cast iron is to deliver and maintain a critical degree of heat at the weld so as to ensure the proper fusing of both the parent and the deposited metals without any risk of burning or slagging due to excessive heat. The higher the carbon content of the metal, the lower the proper welding current will have to be, and *vice versa*, or incomplete fusion will result. The conditions are successfully fulfilled by means of a special flat-compounded low-voltage generator, which feeds the circuit through a constant-current controller in the form of a solenoid-operated resistance. This solenoid is in series with the arc, the current through the arc being controlled by automatic variation of a variable resistance in response to the pull of the solenoid, which compresses or relaxes a series of copper and carbon plates. The ordinary carbon resistance can be used, but is not successful, since the plates become very dirty, thereby causing excessive heating. There is, in addition, a pilot motor, operated by a switch at the welding-tool handle, by which a further adjustment in resistance can be made, so regulating the amperage that the operator can change the arc current without leaving his work. This is very essential when building up a large patch, as the heat increases with the deposition of the metal, owing to the path of the current lying through the deposit; and as it is essential, in order to ensure a successful patch, that the temperature of the deposit should be kept as low as possible compatible with complete fusion, a gradual reduction of arc current is necessary. This is known as the Wilson or constant-potential system, in which an open-circuit voltage, not exceeding 35 volts, is used.

The work was subsequently inspected and passed by the insurance company. As an additional safeguard, the outer rope-groove on each side of this flywheel has since been wound with about 1,500 yards of No. 13 gauge mild-steel-wire, put on under tension, and subsequently soldered down and made secure with tin strips every foot apart. The engine was subsequently run up to quarter speed, and after a short time tested, this operation being repeated with increased speeds, and eventually, no signs of weakness being evident, it was put under load. It has since been running for 23 hours out of every 24, the longest consecutive run being one of 132 hours, and the flywheel appears to be quite sound.

The Cause of Defective Castings.*

By Herbert W. Ramp.

Every person intimately connected with the foundry industry realises the importance of the entry "Defective Castings" in the records of the business and views the percentage with apprehension when it begins to ascend. This is the most constant point of leakage in the foundry and shows a clear-cut wastage that is often quite unjustifiable.

It is scant satisfaction to a customer to know he gets a slightly superior quality, or a little lower price, if he cannot get the material to fill the orders on his books, or maintain his schedule because the foundry has made so many defective castings, and it is equally galling to the management to see its profits absorbed by this item.

The old questions are still being asked: "Why is it that 5 to 15 per cent. of the castings made have to go back to the cupola as scrap?" "Why can a moulder make ten good castings and then lose five?" "Has the foundry business no real foundation for its practice?" One answer often given, "It is the human element," has more significance than is usually accorded it, and some points in its application may be profitably considered.

There are few standards or definite formulæ in foundry work. Every foreman is a law unto himself. He has been educated, not in the school of chemistry or mathematics, but in first-hand experience. No one prescribes for him how his sand must test, what percentage of moisture it may contain, or how he must pour or vent a certain piece. He has worked on certain lines with certain material, and produced satisfactory results; he naturally feels that he is the Moses to lead the way out of the wilderness, and often a temporary success makes him feel his judgment is infallible. He closes his eyes and ears to what others are doing, with the result that when trouble comes he has nothing but his experience to fall back on. He has contested or discounted every other man's efforts until he is unable to absorb other's ideas, and he has to stand or fall upon his own necessarily narrow information.

This is the first "human element" in the foundry—the mind that directs the practical operations. The foreman must be broad enough and clear enough of vision to keep in touch with the progress and development made by his men if he expects to conduct the business profitably.

Again, workmen in the average foundry do little routine or automatic work. They may be employed upon the same class of product, or even the same pattern, but the changes in the material or conditions, the character of the operations, the dependence of one branch of the work upon another, call for the constant exercise of judgment on every casting made. The moulder must make the casting, not as the contractor builds the house, according to plans and specifications, but so that the completed casting will be satisfactory. He may often be called upon to make one that has never been moulded before, for which there are no gauges or templates, text books or standards to guide him. He must be the pioneer, and initiate his own way to success. His judgment and interest in his work make him a good mechanic or a poor one.

Coupled with these variations of work, a great influence is exerted by the physical and mental condition of the workman. His habits of life, his health, the state of his home life, all have a bearing on the quality of the work he produces, and thus "human element" demands that the foreman should study the individual ability and habits of his men to determine their fitness to produce the kind of work desired.

Because a certain moulder is paid the ruling rate of wages or has served a regular apprenticeship at the trade does not decide that he is capable of making a good automobile cylinder or a lathe bed. Engage and educate a hundred moulders, and there will be found a hundred varying shades and degrees of workmanship and ability. It is as important to select the right man to perform the work as it is to choose the material or equipment used in its production, for foundry work is rarely routine. One cannot set the speed and feed and leave the workman to stop and start the machine. He must use his brains, and when he neglects to do this defective castings increase and costs ascend.

The raw material furnished to the foundry is another important factor. It is not enough that it should be a standard make, or that it meet certain chemical specifications. It should above all else be uniform. This is often more important than the grade of material purchased. The foundry foreman and employés learn by practical contact with the supplies the best way to use them. Often without warning changes are made without the knowledge of the foundry. A new brand of pig-iron or a new coke has been purchased; and has been secured from different pits, or other supplies furnished from new sources. While the materials may be equal in quality to what they were using, it is strange country to the men, and the foundry goes through a period of experimentation and loss before they forget how to use the old material and learn how to use the new.

The "human element" has been at work in the purchasing department. In their desire to make a showing for their end of the business, the buyers have substituted new material for that against which there was no complaint, perhaps because the new could be purchased slightly cheaper, and the results in the foundry may be loss and defective castings.

A case recently came to the notice of the author where castings were constantly showing up defective for several months. One week they would be good, the next week they were condemned. Everything possible in the way of practice was tried without avail until a survey of all the material used showed the contract for the sand used in making the moulds had been divided. Part was furnished by a dealer who knew what the foundry wanted and part by a dealer who did not know. The sand from both was unloaded in one bin for the winter's supply. One grade was all right and the other was not. When the sand that was unsuitable was used the castings were bad; when a vein of the good sand was struck they were satisfactory.

The small saving effected in purchasing was lost a hundred times over in the foundry. The purchasing agent's duty to buy cheaply is unquestioned, but he should consider, first, that satisfactory material is of the greatest importance; that different men give their material different treatment. If it seems wise to change, and often it may be, the change should be made with the co-operation of the shop man. The material should be tested and proved out by the men who must use it, and a uniform and constant quality supplied as far as it is humanly possible.

Due to the lack of standards and the need of uniformity in supplies furnished the foundry, it becomes a fertile field for experimentation. When trouble occurs and a defective castings result, the man in charge turns to other methods and ways of doing the work, and that is the time when sound judgment must be used.

There are so many ways to make a casting bad; so many different things can cause the same defects, so many workmen contribute to its making, that the real cause of trouble is often obscure, and sometimes the best men fail to diagnose the symptoms correctly, so that when a radical change is made it must be watched and tried and tried again.

It is useless to declare the new method a success because it worked all right the first few times. An average over a period should be taken to see if it stands the test of time when the special interest and attention that are given to the novelty are withdrawn. It must be proved right before making a truckload of work that may be rejected, for the most experienced may overlook some point or some unforeseen trouble may develop.

* Extracted from "The Iron Age."

New methods should not be avoided; they should be sought and cultivated. It is the road to progress and good castings; but enthusiasm over an apparently successful new method should not be allowed to lead into a heavy loss.

A common reason for defective castings is that many foremen do not prepare ahead to overcome known trouble. A certain casting will be ordered, and many will be spoiled; but finally the order will be filled, and the pattern sent back to storage. Later the same casting will be ordered again, and the same casting will be gone through until that particular pattern grows to be considered a Jonah, and is feared by the entire organisation.

These are the jobs that run up the percentage of defective castings—the ones that are not mastered. When one loss has been sustained on a pattern, the foreman should set himself to work to control and correct that trouble. The time for experiment and study is when there is no order crying for production, when careful research can be made, even though it means making some castings that are not on order and may never be used. It is a great deal more economical to make a few castings experimentally that will be scrapped than to lose 10 or 20 per cent. of an order when the shop demands the product. Besides, this is taking the right attitude toward defective work—meeting it face to face and fighting it out, not heaving a sigh of relief when the order is filled.

Again, many foundry troubles arise from the design. The engineer makes his designs according to his own ideas. He does not know that the changing of the thickness of a section, the addition of a lug or boss, may change the manner in which the shrinkage of the iron occurs.

It may seem impossible that a small deviation from a tried design will give the foundry trouble: yet this is often true. And the foundryman may look everywhere else—to his iron, his coke and his sand—before he finds out that the design was the real reason for the defects. This point must be studied by the foundryman. He cannot expect his engineer to know how molten metal acts in a mould. He does not always know himself. The engineer must be open-minded enough to co-operate and change his design where practical, and when requested by the foundry. An hour's work in the engineering department has often saved hundreds of pounds in the foundry.

The Annealing of Aluminium.

According to "Autogenous Welding" aluminium castings such as oil pans of motor cars are somewhat difficult to weld when broken, owing to the liability of the part drawing out of shape while cooling, or cracking owing to the locked-up stresses. If the part changes shape much it will be impossible to reassemble it, and if held rigidly to a steel frame while cooling so as to maintain the original form there is danger of cracking.

One of the most effective materials for insulating pre-heated aluminium castings and preventing cracks while cooling is dry soft-wood sawdust. The sawdust should be used liberally, covering the welded casting to a depth of, say, 2 in. If dry it is an excellent insulator, and if the casting is quite hot it is likely to take fire and smoulder slowly, thus extending the cooling period considerably. An aluminium casting so treated will be so well annealed when cooled that it can be bent without fracture.

In this connection it is of interest to note a method employed by coppersmiths to anneal large copper and brass sheets and keep them flat. The same method is used for aluminium and monel sheets. After being heated the sheets are laid between dry pine boards and left to cool. The boards are excellent heat insulators, and as the wood chars and smoulders for a time the slow combustion helps to maintain the heat. The sheets cool very slowly, and when finally cool will be found soft and easily bent.

Smethwick Foundry Company, Limited.—It was resolved, October 18: That it is advisable to wind up the company voluntarily. Mr. R. T. Hall, 109, Colmore Row, Birmingham, C.A., has been appointed liquidator. Claims to liquidator by November 14.

The Determination of Arsenic and Antimony in Brass.

By F. A. Livermore.

Reagents Required.

Zinc Chloride.—This is prepared by adding an excess of 99.50 per cent. (As and Sb free) spelter to HCl (s.g. 1.1); when the action has ceased, any residue is filtered off, and the filtrate is evaporated until its boiling point is 108 deg. C.

Ferrous Chloride.—A 50 per cent. solution of $FeCl_2$ in water.

Ferric Chloride.—32 grams of Fe_2Cl_6 dissolved in 500 c.c.s. water.

Hydrochloric Acid.—S.g. 1.16, special, free from As and Sb.

Iodine.—N/100 solution.

Sodium Bicarbonate.—A saturated solution in water, 10 c.c.s. of which should not give more than a faint coloration with 3 drops of phenol pthalein.

Potassium Bromate Solution.—N/100 solution.

Precipitation of Arsenic and Antimony.

13 grams, or more, according to the percentage of arsenic and antimony supposed to be present in the brass, are dissolved in 75 c.c.s. HNO_3 (s.g. 1.42) and 25 c.c.s. HCl (s.g. 1.16); 1 c.c. of ferric chloride solution is added, and the liquid is diluted with distilled water to about 600 c.c.s.

It should be noted that concentration of liquid is an important factor in precipitation, and to obtain the best results the given data should be carefully studied and continually borne in mind, when it should be possible to report a result with an accuracy of 0.001 per cent. The liquid is boiled, and a boiling saturated solution of sodium carbonate is added until a slight permanent precipitate appears, after which 1 c.c. of carbonate in excess is added. Allow to stand for 15 minutes, filter, and dissolve the precipitate in HCl (s.g. 1.1). Make up the solution to 600 c.c.s. with water, boil and re-precipitate with ammonium hydrate. The settled precipitate of iron hydrate is filtered off and washed free from ammonia with hot water, thorough washing being necessary at this stage because of the reducing action of ammonia. The precipitate is dissolved in the least possible quantity of HCl (s.g. 1.1), and transferred to a distillation flask through a dropping funnel.

Distillation.—Add 75 c.c.s. zinc chloride solution, 10 c.c.s. of special HCl (s.g. 1.16) and 5 c.c.s. ferrous chloride solution. Boil the solution until the temperature is 116 deg. C. Add gradually through the dropping funnel 90 c.c.s. of the special HCl, keeping the temperature as near 116 deg. C. as possible. The distillation should occupy about one hour. While the acid is being added, the distillate is collected in a beaker beneath a Davis condenser. If there is an appreciable quantity of arsenic present, the distillation should be repeated with quantities of 20 c.c.s. of special HCl until all the arsenic has been distilled, allowance being made for the blank on the estimation.

Distillation of Antimony.—The liquid left in the distillation flask is heated until the temperature is 150 deg. C., and 75 c.c.s. of special HCl are added during the course of 1½ hours, keeping the temperature constant. The temperature is then rapidly raised to 200 deg. C. with a naked flame.

Estimation of Arsenic.—Neutralise the distillate obtained during the hour at 116 deg. C. with $NaHCO_3$, and titrate with N/100 iodine, using starch as an indicator. If arsenic is present, the distillate obtained on distilling for 20 minutes with 200 c.c.s. of special HCl is titrated in the same manner, and the amount, less the blank, is added to the first.

Estimation of Antimony.—(*a*) Add a little tartaric acid, and neutralise the solution with $NaHCO_3$. Titrate with N/100 iodine: or (*b*) heat the distillate to boiling, and titrate with $KBrO_3$, using methyl orange as indicator.

Blank Estimation.—The process of distillation and titration for arsenic and antimony in the reagents used should be carried out periodically.

Southern Metal Presswork Company, Limited.—It was resolved October 10, and confirmed October 18: That the company be wound up voluntarily. Mr. E. G. Willson, 80, Gracechurch Street, E.C., has been appointed liquidator.

Foundry Re-organisation.—Part VI.

By H. W. J.

No business can be run without a system, and no matter how haphazard the foundry appears to be conducted, somewhere there is the basis of a system, and this must be discovered and exploited.

The system is necessary to ensure efficient working and intelligent management, and so long as it is understood and made use of, its value is apparent. System is not a conglomeration of forms and records, of book-keeping and charts, but is the visible sign of the policy adopted.

It is designed primarily to stop waste—both of time and material, and in so doing it ensures expenditure being productive. It is recognised that money must be spent before money can be earned, and system must show not only how much money is being spent, but how and why it is being spent, and, afterwards, what return has been made.

A business is run with the idea of making profits, and it is of no use filling the foundry with orders if these are to be executed at a loss. On the other hand, the foundry is of no use if orders are not forthcoming, and inducements must be offered to secure them. These inducements may be classified as follows: (*a*) Price, (*b*) delivery, (*c*) workmanship.

These three factors are interdependent, so long as the values are relative. An extremely low price may secure an order, but inferior quality castings or a protracted delivery will effectively prevent the securing of a repeat order. Value for money, and not apparent bargains, is what the customer asks for, and it is to ensure the lowest price for a certain quality casting, on a reasonable delivery, that the system is put into operation.

We are, of course, dealing with the reorganisation of a foundry already in existence, and which has a certain reputation. There is also a certain amount of data available, which can be used as the basis for future operations, and this will be wanted when we realise that we have to give a quotation before we can secure orders.

No customer will present us with a blank cheque by allowing us to use his order as a means of determining the cost. He wants to know, before he places the order, the price demanded, and this must be given. And, badly as we want his order, it must be to us a paying proposition, or it is worse than valueless.

We know the quality of the product, and it should be known whether the quality will suit the prospective customer. Such conditions being satisfied, an estimate must be presented sufficiently high to yield a fair margin of profit, and sufficiently low to act as an inducement to the customer. Having compiled the estimate, we must *know* that it is an economic figure, and also that it is the lowest economic figure.

We must, then, have a system which will enable us to keep accurate cost records—nothing elaborate, but something effective. We lead off by instituting a method of book-keeping which will give the initial particulars of the orders we have received—the date the order was received, the quantity and particulars of the castings, the price, and the delivery. It will tell us also whether we have to make patterns or whether they have been supplied, and, if the latter, whether they be made of wood or of metal, and the number of patterns so supplied.

The office record will note also what marks appear upon the pattern and the customer's name and his order number. This information must be set forth so that an intelligent order can be issued to the foundry, for, obviously, were the whole of the particulars definitely given upon the foundry order, there would be a good deal of confusion.

The shop foreman requires just the particulars which are necessary, and these should be issued clearly and concisely. So, arising from the office system is the shops system, this latter being devised to facilitate progress.

The principle to be observed is the maximum output, but this output must comprise those castings which are the most urgently wanted. Tonnage alone is no longer the alpha and omega of the foundryman's creed, for the importance of satisfying the customer's requirements is recognised. Not that tonnage is neglected, for, as before stated, we still work for the maximum, but we have given up dodging that intricate bit of work which contributes so little to the total weight, recognising that we can handle this and still show the maximum return.

FOLIO C
27

DAY BOOK. ORDERS.

Patterns.

Foundry Number.	Date.	Customer's Name.	Customer's Address.	Customer's Order.	Dated.	Type of Casting	Quantity	Name of part	Price.	Delivery.	To be Made.	Supplied by Customer.		
												Quan.	Kind.	Marks.
2000	7/11/21	*Smith & Co.*	*Blankwell*	*4736*	*5/11/21*	*Grey iron*	*2000*	*Supports*	*34/- cwt.*	*Commence 10 days, 200 sets weekly.*	*No*	*1*	*Plate*	*147A.*
1	"	"	"	*4736*	"	"	*2000*	*Crosspieces*	*30/- cwt.*	*Ditto.*	*No*	*1*	*Plate*	*189B.*
2	"	"	"	*4736*	"	"	*4000*	*Guards*	*33/- cwt.*	*Ditto.*	*No*			*173A.*
3														
4														
5														

FIG. P.C.

The cast takes place in the afternoon, and before the hour appointed everything must be in readiness. This means that every morning the amount of work that is to be put in hand is known, and how much of that will be ready for the afternoon cast. Each charge-hand works to a programme, and if it is not possible for every item to be handled there must be some explanation.

In a previous article we spoke briefly on the shop layout in regard to the class of manufacture and

the methods of moulding, and these are factors which, of course, determine the system. Assuming that the foundry is engaged wholly upon small work of a repetition character, and that practically the whole of the moulding is handled by machine, it is not difficult to compile the daily programme and carry it into effect.

The official order, being booked, is passed over to the shop's order clerk, and a separate shop's order for each of the foundry numbers appropriated is made out and sent to the progress department. The shop's order is illustrated by diagram PF.

Upon arrival in this department each shop's order is treated entirely upon its merits, and it is here that the daily programme is compiled. The operators' work cards are made out, and it should be observed that these are made out, not for the full number of castings on order, but for the number to be handled in accordance with the programme. So, assuming that the number on order is 2,000, and that one moulder can handle 200, then the card is made out for this amount to-day and another card for a similar amount when next that order appears on the programme.

If there is more than one pattern, and it is necessary for a daily cast of more than the 200

ORDER.

No. 4736.

From SMITH & CO., Blankwell.

To *Messrs. Brown, Jones and Robinson, Fairfield.*

Please Supply: Date: *Nov.* 5/21.

Quantity.	Description.	Price.	As per
	Pattern No.		
2,000	*C.I. Supports, 147A*	*34/- cwt.*	*Your quotation of the 28th ultimo.*
2,000	*C.I. Crosspieces, 189B*	*30/- cwt.*	
4,000	*C.I. Guards, 173A*	*33/- cwt.*	

1 Plate Pattern each sent you to-day per G.C.Rly.
Delivery. Commence 10 days. 200 Sets weekly.

For Smith & Co.
J.T.

Form P B.

It is assumed that a bonus or a piece-work system is in operation, and the moulding times being predetermined, the daily output from each machine can be calculated. This being so, operation cards are issued to each operator, the commencing and the finishing times being shown upon the back of each card.

SHOPS ORDER. No. *2000.*

To *Mr. Sands.* Date: *9/11/21.*

Quantity.	Name of Part.	Pattern No.	Remarks.
2000	*Supports.*	*147A.*	

Patterns.	Delivery.
1 Plate Pattern marked 147A.	*200. 16/11/21, and 200 weekly.*

WORK TICKETS. (For Coremakers' Orders, see over.)

Ticket No.	Quan.	Date Issued.	Date Completed.	Quan. Passed.	Wasters	Ticket No.	Quan.	Date Issued.	Date Completed.	Quan. Passed.	Wasters.
308	*200*	*12/11/21*	*15/11/21*	*198*	*2*						
320	*200*	*19/11/21*	*22/11/21*	*200*	—						

ORDER COMPLETED. Signed. Foreman.

Form P.F.

For convenience of the shop, the foundry uses its own order numbers, and these are allotted by the costing department. It will be observed that each customer furnishes his own order number, but this is for his own use, and could not be used advantageously in the foundry.

If there is more than one pattern, and it is necessary for a daily cast of more than the 200

FOUNDRY NUMBERS—APPROPRIATIONS.

Foundry Number.	Date Appropriated	Customer's Order No.	Customer's Name.	Quantity and Name of Part.	Day Book Folio.	Works Order Issued.	Completed.
2000	*7/11/21*	*4736*	*Smith & Co.*	*2000 Supports*	c 27	*9/11/21*	
2001	*7/11/21*	*4736*	*Smith & Co.*	*2000 Crosspieces*	c 27	*9/11/21*	
2002	*7/11/21*	*4736*	*Smith & Co.*	*4000 Guards*	c 27	*9/11/21*	
2003							
2004							
2005							
2006							
2007							

Form P.D.

The official order of the customer is set forth on Diagram P.B., and Diagram P.C. shows the order booked. It will be observed that a foundry number has been placed beside each order, and it is against this number that all direct costs are charged. How the foundry numbers are identified with the customer's order is shown on Diagram P.D.

referred to, a card is made out for another operator, but all cards issued in connection with one shop's order must bear the same number, and a record of all cards issued must appear on the order.

The system of payment determines the quantity shown on each card, but the card should cover a full day's work. It may be that the time

allowance for 200 extends well into the next day, but as bonus must be earned the 200 must be ready for the first day's cast. On the other hand, the time allowance just covers the day, so that if bonus is to be earned the 200 must be completed some hours earlier. As no point would be gained in stopping the moulder immediately the 200 were ready he is allowed to go on, and the card is altered at the end of the day to cover the number actually produced, the extra quantity being reckoned as bonus.

As in many cases cores are necessary, orders must be issued to the core-making section, these being in the form of cards, as previously described. It is understood that the cores must be ready by the time they are required by the moulder, and the order is issued early enough to permit this. The order number covering this work must be the same as that covering the moulding, so that all the charges are made against the correct order.

This, of course, covers the production of castings in fairly large quantities, but the same procedure can also be adopted in connection with the production of special castings, which are in all probability fewer in number. The method aims at the correct apportionment of costs, and if this is achieved then much has been accomplished.

The delivery question is also dealt with by this method, for each charge hand is held to the programme. After the casting, too, comes the inspection, and responsibility for "wasters" is definitely brought up against the operator. The inspector's report not only shows the number of "wasters" from the whole cast, but also the number off each order, and the operator's card is endorsed accordingly.

By this method it is possible to compile accurate costing records, whilst the claims of each customer are dealt with upon their merits. A return, showing the order numbers included in the cast, together with the particulars of castings, is sent to the office on the morning following the cast, and when in due course the weight booked against each order is received, it is an easy matter to add the material costs to the record.

The Determination of Copper, Iron, and Nickel in Brass.

One gram is dissolved in 7 ccs. of HNO_3 (S.G. 1.2) and 6 ccs. of H_2SO_4 (S.G. 1.27). When dissolved about 90 ccs. of water are added and the solution electrolysed at 3 amps. 3 volts, using a weighed platinum revolving cathode until the solution gives no precipitate when tested with H_2S water; this usually taking from 15 to 20 minutes. The cathode is quickly removed from the machine, washed well with water and alcohol, and dried in a steam oven at 100 deg. C. From re-weighing the percentage of copper can be calculated.

Determination of Iron.—The electrolysed solution from the copper estimation is boiled down to about one-third its bulk, and oxidised with five or six drops of nitric acid (S.G. 1.42). The solution is made ammoniacal and the Fe $(OH)_6$ allowed to settle; it is filtered off, washed and dissolved into a 100 cc. flask with dilute HCl and made up to the mark. 10 ccs. are taken and transferred to a Nessler tube together with 8 ccs. HCl (S.G. 1.1) and 5 ccs. ammonium sulphocyanide and made up to 50 ccs. with water. To another tube 10 ccs. of HCl. (S.G. 1.1) and 5 ccs. ammonium sulphocyanide are added, and made up nearly to 50 ccs. with water. A standard iron solution (containing 0.5 grams of Fe pepr litre) is added until the tint is the same as the sample: from the number of ccs. used the percentage of iron can be calculated, since 1 cc. of iron solution = .0005 grams Fe.

Determination of Nickel.—The filtrate from the precipitation of iron is made faintly acid with acetic acid and just alkaline with ammonium hydrate, using methyl orange as indicator; 20 ccs. of a 1 per cent. solution of dimethyl glyoxime in alcohol is added and well shaken. The precipitate of nickel is filtered off, washed well with water, and transferred to an evaporating dish. The water is evaporated off, and the dish and contents dried in the steam oven and weighed until constant.

Factor to nickel = 0.2107. F.A.I.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Sand-Mill Troubles.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have read with interest the query about sand mill troubles by "Anxious" and can assure him that he is not alone in this respect. I put in a centrifugal machine to break up lumps and cakes, but the defect in sand mill still remains, and the driving belt has to be continually tightened, the scrapers readjusted, and occasionally the 20-h.p. motor, which drives the sand mill and a pair of grinders only, is stopped through overload.—Yours, etc., H. B.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—The trouble which "Anxious" outlines is a real trouble, and in large establishments is generally overlooked, due to the manager erroneously thinking that there are more important matters requiring his attention. Added to the rough usage of belts, there are endless stoppages. The necessity of procuring another machine, as, for instance, a centrifugal machine, is only a subterfuge, and makes matters worse.

Some weeks ago, whilst on a "busman's" holiday in the South of Scotland, I saw in another foundry a sand mill which certainly seemed to act efficiently. The manager of this foundry had had the trouble mentioned by "Anxious," and overcame the difficulty by preparing a pair of wheels different from the usual type. The old wheels or rolls which were discarded weighed over half a ton each, and were replaced by a pair with large flat teeth 3 in. wide, and spaces 4 in. wide, each wheel weighing approximately 2½ cwts.

The results were extraordinarily good, and necessitated very little new sand being used. A large quantity of sand could be worked without blocking the machine, the sand, when discharged, being tough, well mixed, and free from hard cakes. Protection has been obtained for the modification, and its appearance will be welcomed by many foundrymen.

Power in this particular foundry was unlimited, a good supply of water was available, but still the belt trouble persisted.

The manager is a thoroughly practical man, and I saw results which were very satisfactory, castings such as exhaust pipes having thin webs or radiators on top, and other castings requiring a good tough well-mixed sand.

Unskilled labour was another factor which compelled this concern to devise some means of improving his sand.—Yours, etc.,

FOUNDRYMAN.

117, Park Street, Oldham.

Furnace-Lining Compo.

We have received from Messrs. Thos. E. Gray & Company, 119, High Holborn, London, W.C.2, a leaflet dealing with their "Silacene" furnace-lining compo.

Silacene compo is a silica-alumina mixture of the correct proportions from which lime has been eliminated by a special process. The silica is in the form of impalpable powder, and when mixed with water this composition becomes very adhesive and sets like portland cement when exposed to heat. Owing to the closeness of the grain it resists the cutting action of the gases in the furnace, and no lime being present in its composition it is unaffected by slag.

Lining is effected by first removing the old brickwork and inserting a pattern of the required diameter, about 18 in. high. An old pulley ring is often employed for this purpose. The space between the pattern and the shell is then filled with the moist compo, pressing each ball firmly down with a rammer, drawing up the pattern as the work proceeds. When the lining is completed, a slow fire is maintained for about twelve hours to dry off the compo.

Operating Details of Electric Furnaces.*

By Edward T. Moore.

The question continually arises as to the limit that should be set on transformer primary voltage for electric-furnace service. Transformers ranging from 50 to 22,000 volts are common, and from the transformer standpoint there is hardly any reason why the high voltage should not be doubled or even quadrupled. However, there are deciding factors that enter into the situation.

With a voltage higher than 22,000 the type of oil switch necessary for safely rupturing the current changes to a design that is expensive to install and operate. Accordingly, for 44,000 volts and higher, especially in small units, it is desirable to make the first step from the line voltage to 6,600 volts or 2,300 volts, depending on circumstances.

Automatic Control.

The task of keeping the power input to an electric furnace constant, within reasonable limits by maintaining the position of several electrodes, with their supporting mechanism and flexible conductors, is not an easy one even when all arcing surfaces are comparatively stable, but when half of the arcing surface is made up of numerous pieces of metal constantly changing under the action of the arcs the difficulties are considerably increased. From the surface of the molten metal there is a continuous spray of small metallic particles, which makes it easy to establish the arc before the electrode touches the metal, but with solid metal the electrode must practically come in contact before the arc is struck and must then be drawn away quickly so as to minimise the current surge. This is the condition met in the first part of melting down a charge of cold steel scrap, and is a trying time to all parts of the equipment.

Automatic electrode regulators have been commercially used in Europe for twenty-five years, and in the U.S. about fifteen years, in both places demonstrating to the user their value in effecting better results and conditions generally.

Compared to the inefficient human machine, a small relay follows the impulses continuously, and the automatic regulator throws a switch as soon as the change takes place in the circuit, the electrode moving almost instantly to meet the new conditions.

In operating an electric furnace it is desirable to keep all surges within the closest reasonable limits, as these surges have, in practically all cases, a definite bearing on the cost of power, and even when this is not considered, such surges affect other users and frequently cause prejudice against all electric furnaces. Momentary surges are limited by electrical characteristics of the furnace circuit, while the duration of the sustained surge is determined by the electrode control. A sustained surge tends to carry the current density far above the normal carrying capacity of the electrodes, electrode holders and conductors. As the heating varies directly with the square of the current, a current increase of 50 per cent. will increase the heating 125 per cent. above normal, and accordingly shorten the life of any current-carrying member, especially contact surfaces. The electrode consumption is also increased when the power is permitted to vary over wide ranges, and surges tend to cause overheating at weak spots in the electrode, with consequent deterioration. In addition to this important consideration, there are others of almost equal importance, such as the effect on the quality of the product due to widely varying temperatures at the surface of the metal, effect on the equipment, especially the transformers, due to surge strains, etc.

Arrangement of Electrical Apparatus.

With several exceptions, practically all furnace equipments are installed in a straight line—that is, the transformers are situated directly behind the furnace, and the direction of motion during tilting is directly away from the transformers. While this method of installation requires somewhat longer flexible leads, there are no side strains to the electrode masts, and it is comparatively simple to install apparatus in buildings that were designed for other purposes. As opposed to this arrangement, we have the design where the furnace tilts at right angles to the line from the transformers to the furnace, this arrangement requiring considerably shorter flexible leads, but giving considerable side strains to the electrode masts.

Where one polyphase transformer furnishes power to the furnace, the busbar layout is comparatively simple, but with three transformers it becomes much more complicated. In this connection the question arises of using interleaved buses to indicate where the delta or Y is formed and the flexible leads taken to the transformer, or whether this connection will be made at the transformers and the added inherent reactance accepted as a necessary evil.

The furnace conductors should be so disposed as to avoid unnecessary eddy current losses, which increase the reactance and may cause trouble through distortion of the iron work. Care should also be taken that the panels are kept outside of any magnetic loops or fields, as the instruments may be unfavourably affected.

Busbars are usually self-cooled, but an unusual exception is found on two 10-ton furnaces in America, where the connections from the cables to the electrode holders are thick-walled water-cooled copper pipes. These conductors have given good service during several years' operation.

Flexible cables are necessarily used between the transformer and furnace buses, and a form of insurance is the use of welded terminals that absolutely do away with shutdowns caused by failure of soldered or brazed terminals.

The current density is usually somewhat higher in the cables, approximately 900 to 1,000 amp., than in the bars, which usually run 750 to 850 amp. per sq. in.

On account of the height of the electrode masts, in those cases where the conductors are carried over the tops, a saving in bus copper can be effected by raising the transformer on a pedestal, so that the top of the low-voltage leads is on a level with the top of the masts.

Variable or Dual Voltage Control.

An important subject is the use of double voltage operation for arc furnaces, is important not from the standpoint of range of voltages to be used, but also the possible detrimental effect of increased rate of melting, obtained by the use of such voltages, on the quality of the metal.

With small furnaces up to one or two tons capacity, except in special cases, there seems to be little reason for going to the expense of installing apparatus for double voltage control. In larger furnaces, however, good reason appears for using a high voltage during part of the melting period and a lower voltage during the refining period. With a furnace taking 1,500 k.v.a. the voltage applied to the electrode must necessarily be a compromise between a value that will not be so high as to damage the roof and side walls during refining or so low as to lose too much time during melting.

By the use of dual control a voltage can be chosen for melting that will give the best results for this so-called heavy duty work, while a corresponding value can be chosen for the refining which will give the best results during that important period.

In one installation the greatest power input that could be obtained during the melting down period was 1,800 kw. at 100 volts, while with practically the same furnace design the power input was increased to 3,200 kw. by a moderate voltage increase.

There is a well-defined belief that the high rate of melting obtained by high voltage is detrimental to the quality of the product, especially for tool steel, and this should be carefully investigated. Until the arc shows above the metal, there can be no other objection, and possibly the same holds true for the quality of the metal.

* Excerpt from a Report of the Electric Furnace Committee o the American Association of Iron and Steel Electrical Engineers Extracted from "Chemical and Metallurgical Engineering."

Reactance.

The amount of reactance to be used with an electric furnace; its disposition on high-voltage or low-voltage side; the amount of inherent reactance in the transformers; the kind of reactor, iron core or air core, depend upon the type of furnace, the service and local conditions. The reactance stabilises the arc and determines the limit of short circuit current. The resistance of the leads, electrodes and charge being small compared to the reactance, can be neglected in this connection.

A 6-ton three-phase furnace having transformer capacity of 1,500 k.v.a. on a 60-cycle circuit will have approximately 90 per cent. power factor, indicating a reactance of 43.6 per cent., of which about 6 per cent. will be in the transformers. The remaining 37.6 reactance, which is principally in the secondary leads, would be reduced to 15.7 per cent. on a 25-cycle circuit. The 25-cycle transformer would have a reactance of about 7 per cent., which, added to the 15.7 per cent., would give a total of 22.7 per cent., indicating a power factor of 97.4 per cent., with a corresponding short circuit current of 440 per cent. This indicates that to give the smooth operation of a 90 per cent.

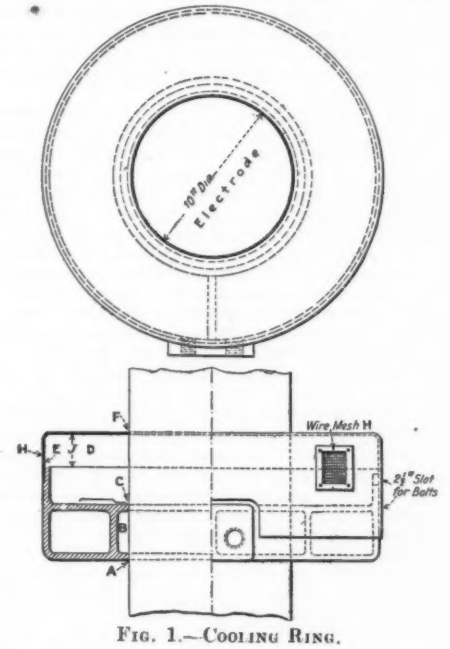

FIG. 1.—COOLING RING.

power factor furnace a 20 per cent. reactance should be added to a furnace that normally requires no exterior reactance on a 60-cycle circuit.

Except on small furnaces or very high-voltage circuits, the use of external reactance is practically confined to the high-voltage side. In this position it gives additional protection to the transformer against exterior surges, and is easier to install on account of the general arrangement of apparatus.

Transformer Reactance.

The inherent reactance of a transformer with normal design is from 4 to 7 per cent., and this can be increased without much difficulty up to 20 per cent. If additional reactance is to be installed and it comes within this value, it would be a mistake to keep down the transformer reactance and then increase the installation cost by adding external reactance. This is not necessarily the case, as the equipment will be considerably more flexible if the inherent or uncontrollable reactance is reduced to a minimum and desirable characteristics are obtained by the use of external or controllable reactance. This is especially true in installations using variable voltage control, as the amount of reactance necessary to produce the best results at the high voltage would be excessive, and produce undesirable characteristics at the low voltage.

Under ordinary circumstances the choice of reactor lies between the iron core type and the air core type, in some cases there being little to choose from the standpoint of price alone.

The iron core reactor is chiefly used in circuits carrying currents of less than about 50 amp., when a reactance of more than 4 or 5 per cent. is required. Under such conditions an air core reactor would require a very large number of turns to give the desired reactance, and the iron core design is considerably more economical.

Electrodes.

The function of the electrode is to conduct electric energy into the furnace and assist in the production of a proper atmosphere for refining of the metal. Since the cost of electrodes will form approximately 9 per cent. of the total operating expense of a furnace, it will be appreciated that this subject is an important one. This expense will be further increased if excessive breakage is experienced, and from the questionnaire below it will be noted this item amounted to an average of 7.7 per cent. for carbon electrodes. In addition to this, delays on the furnace due to electrode breakage are costly items, and may become prohibitive.

It is believed if more attention was directed toward the proper handling of electrodes by furnace users that excessive breakage would be eliminated and higher economy secured per ton of metal produced. The average consumption of carbon electrodes taken from our questionnaire is 39.9 lbs. per ton of metal produced, although there are a number of cases where 30 lbs. per ton of metal is an ordinary everyday performance. There seems to be much room for improvement toward better electrode economy, by better methods of handling and storage of this important material. With proper handling by the consumer electrodes should give better service than the average records indicate, for better electrodes are now being made.

The average electrical resistivity of graphite electrodes should be 0.00036 ohm per inch cube, or 0.000914 ohm per cm. cube.

As a means of securing better electrode economy more attention should be given to roof cooling rings for the purpose of reducing "spindling" and "wasping." The gases generated in an electric furnace during operation are only combustible at high temperatures, which means that if they escape to the atmosphere they are hot enough to burn, and in doing so burn up part of the electrode itself, and also have a very objectionable effect on the electrode holder. Consequently, nearly all the present-day cooling rings have for their principal object the cooling of the electrode and the cooling of the port holes of the roof.

In the cooling ring shown in Fig. 1 there is obtained the desirable feature of keeping the roof port holes cool, keeping the electrode reasonably cool, and go still farther by cooling down the gases, as they leave the furnace, to a temperature at which they will no longer burn when they meet the oxygen of the atmosphere.

While these gases are inside the furnace they are under reducing conditions, and have, therefore, only their own sensible heat and no heat generated by the oxidation of combustible constituents. These gases pass, first of all, in between the electrode and the port hole of the roof, and then pass through clearance *A* (Fig. 1), in the cooling ring and into a relatively larger chamber *B*, which causes the expansion of the gases, thereby giving up a large amount of sensible heat. This heat is absorbed by the water in the cooling ring. From chamber *B* they are once more contracted through the small clearance *C* and are passed to a very large chamber *D* for a second and much larger expansion. This chamber is surrounded, in the case of graphite electrodes, by a thin enclosed cover *E*, which in actual practice has been found quite sufficient to dissipate the heat given up by these gases, and when they finally pass through the clearance *F* they are no longer at a temperature sufficiently high to cause them to burn in the atmosphere.

The fact that graphite electrodes can be machined allows the use of a very small clearance at the points *A*, *C* and *F*, which in turn allows a much larger relative expansion into the chambers *B* and *D*, and at one installation it has been found that even during the periods when carbon is being thrown on to the slag for the purpose of deoxidation, there is not the slightest sign of flames being emitted at the point F, and the

electrodes themselves do not show the slightest trace of reduction in diameter.

When such economisers are to be used on amorphous carbon electrodes, and especially of the larger sizes and of the makes where the diameters do not run to any regularity, a change is made in the chamber *D* of the economiser. The gases there, instead of being all allowed to pass through the clearance *F*, pass through perforated plates *H* on the outer wall of the cover *E*, and by keeping these perforations as small as practical, the plates *H* will act on the principle of the metallic gauze used in Davy miners' lamps, in which it is well known that the heated gases of combustion from the lamp are cooled to such an extent that the lamp can be very safely used in the dangerous explosive gases of coal mines.

The cover *E* will be made adjustable, so that the distance *J* can be altered to suit working conditions. This is desirable from the fact that certain types of electrodes may have a greater variation than others, and it may be necessary to increase the capacity of the chamber *D*, whereas for the best type of electrode this distance can be kept down to a minimum, and thereby not affect the maximum travel of the electrode jib.

The use of this electrode economiser considerably decreases the amount of electrode consumption, and the port holes in the roof also appear to stand up very much better. This is probably due to the blanketing effect, and to the fact that the flames do not rush out through the roof. It has also been noticed that there is a much less tendency of the electrodes to taper off and they burn square right down to the point of the arc. This means that the electrode always has the correct carrying capacity at its extremity.

In cases where this type of cooling ring is not used, the air coming in through the furnace doors strikes the white hot electrode, and the roof openings act as a chimney, the electrode burning away and pencilling off. When the tip of the electrode is thus reduced it has often to carry very much more current than it has been designed for, and the consequences are that the electrode heats up unduly throughout its length, and breakages of electrodes and connecting nipples frequently occur.

Experience so far, while limited, seems to indicate that the above objections are very largely prevented by the use of these economisers.

Refractories.

Silica bricks are used as an electric-furnace refractory more than any other material for the reason that the melting temperature is very high, being approximately 1,700 deg. C. They are especially satisfactory for roof brick, as they have an expansion when heated of about 0.25 in. per ft., which permits of maintaining a very flat roof. The bricks are made from quartzite with 95 to 99 per cent. silica (SiO_2), and when furnished should contain at least 95 per cent. silica in order to stand up. Silica bricks should be laid in a siliceous mud for mortar—in fact, all refractory bricks should be laid in mortar of the same composition as the brick, in order to avoid fluxing.

Magnesite bricks are finding an increasingly large use for those parts of the furnace in direct contact with the charge and for parts exposed to extremely high temperature. The finely powdered magnesite is burned so thoroughly that it is sintered and then forced into shape by the use of very high hydraulic pressure. As it shrinks greatly when heated it is again burned before use, and can then be kept in storage without fear of spoiling, for it is not so sensitive to moisture.

Basic mortar must be used with magnesite bricks, and the courses should be laid as close as possible, so that, even with expansion of the mortar, the joints may remain tight and expose very small surfaces of attack to harmful influences. It should be noted that under the influence of other materials at high temperatures certain refractories quickly break down. The following rule must be strictly observed: In the presence of basic influence use basic materials, and with acid influences, use acid materials.

Particular attention should be directed to the building of the side walls in a furnace so as not to have them too steep, else it will be very difficult to repair or patch up disintegrated portions.

Very great success has been secured with dolomite in making bottoms for furnaces. It is a limestone containing a considerable proportion of magnesite, and when burned forms a valuable refractory, but should be mixed with pitch or tar before ramming into the furnace, and used as soon as possible, because of its lime content ($CaCO_3MgCO_3$) it readily absorbs moisture from the air and falls to powder.

Brass-Melting Furnaces.

The reason for the rapid increase in the use of the electric furnace in the conservative brass industry and for melting other non-ferrous metals and alloys is the production of a uniform metal by eliminating or minimising operators' errors under the trying conditions of fumes and high temperatures met while handling crucibles, eliminating contamination from furnace gasses, preventing loss of volatile constituents through uneven heating and, in general, making a uniform product by superior heat control. Another point is that in mixing two or more metals having different specific gravities and melting points, it is necessary to have efficient stirring, and this is accomplished both electrically and mechanically.

Furnaces may be broadly divided into those in which the heat is generated in the metal, those in which the heat is generated at the surface of the metal, and those in which the heat is generated externally to the metal and radiated or otherwise transferred to it.

In the first group there is the induction furnace for normal frequencies, of which there are many in successful operation. These furnaces are very efficient, and are best adapted to large plants where one or more furnaces can be used continuously on the same class of metal. In small plants, or where several heats are to be made of one alloy and then another composition is required, this type of furnace is at a serious disadvantage, as they are usually started with a charge of molten metal. Intermittent operation of this furnace also has a detrimental effect on the lining, and it is practically limited to continuous operation.

Another type that is passing through the experimental stage operates on the induction principle, and is designed to take power at 9,000 cycles or higher. The equipment is very simple from all standpoints except the power equipment, which has been the chief obstacle in the development of equipments of commercial capacity. This furnace can melt or heat any metal to any reasonable temperature, and should be of great value when fully developed.

In the second group there are furnaces where the current passes from the electrode to the metal, and it is necessary in this case to reduce the voltage drop between the electrode and the metal to such a value as will practically eliminate arcing. This is necessary on account of the intense heat developed by an arc in the surface of the metal, causing tremendous vaporising losses which could not be tolerated.

The third class includes arc furnaces where the heat is generated above the metal and radiated to it and the refractory walls. By oscillating or rotating the furnace shell, the metal is mechanically stirred and absorbs heat from the refractories, thus tending to keep them at practically uniform temperature.

Other types of furnaces using exterior heating are resistance furnaces where the heat is generated in resistors and radiated or conducted to the metal. The latter types have neither electrical nor mechanical stirring, and must depend upon mechanical rabbling together with slight stirring, due to heating effect through the lining. Various other types are under development, but they are not of sufficient commercial importance to warrant consideration here.

The consumption of electric energy varies from a reported figure of 174 kw.-hr. per ton in continuous operation on induction furnaces up to 240-500 kw.-hr. for intermittent operation on arc and resistance types.

KITSON (J. W.) & COMPANY, LIMITED, London, E., boiler and steam pipe coverers, etc., in liquidation, Mr. F. S. Salaman, 1 and 2, Bucklersbury, E.C., C.A., was appointed receiver, October 21.

Trade Talk.

A BATCH of ten warships, purchased by the Barking Shipbreaking Company, are to be broken up at St. Mary's Island, Chatham.

PREPARATIONS are being made to blow in a furnace at the Dowlais Works, East Moors, Cardiff, of Guest, Keen & Nettlefolds, Limited.

THE steel works of the Wigan Coal and Iron Company, Limited, were restarted last week, after having been closed down for practically a year.

MR. E. D. ANDERSON lectured to the Paisley Association of Electrical Engineers recently on the subject of "Legal Knowledge Pertaining to Industry."

THE IMPORTS OF FOREIGN IRON ORE at the Senhouse dock at Maryport last month were 3,700 tons, against 4,500 tons for the previous month, and 23,300 tons for the corresponding period of last year.

THE WITHDRAWAL of the war bonus to men in the shipbuilding and engineering trades in Government establishments will take effect from November 25, instead of November 5 as originally proposed.

THE STAFF of the Associated Society of Locomotive Engineers and Firemen have left Leeds to take up duties in London, the headquarters being now transferred from Park Square, Leeds, to 9, Arkwright Road, Hampstead.

A GENERAL MEETING of the York Branch of the Institution of Mechanical Engineers was held in Leeds on October 31, Lieut.-Col. E. Kitson Clark presiding. A paper on "Gaseous Firing for Industrial Purposes" was read by Mr. F. J. Bostock, of Huddersfield.

IN connection with the proposed new swingbridge for Antwerp Docks, altogether eight tenders were received; seven of these were from Belgian firms, and ranged from 360,911 to 439,400 fcs., and one from a Dutch firm for 123,500 florins (say about £10,300 at par).

THE Newcastle Corporation Transport and Electricity Committee have accepted the tender of Bolckow, Vaughan & Company, Limited, Middlesbrough, for 1,500 tons of tram rails at £12 10s. per ton. The nearest foreign tender was stated to be very little below the one accepted.

GERMANY is stated to have secured contracts awarded by the Rand Water Board in connection with the Vaal River water supply scheme to the extent of £280,000. The lowest British tenders are said to have exceeded the German offers by over £100,000, and only one contract has been given to a British firm.

DR. MACNAMARA writes in reply to a question by Major Kelley, in the House of Commons, that the percentage of persons unemployed in the United Kingdom in the iron and steel industry was 29.1 on September 30 last and 27.5 on October 21. The percentage in the Sheffield and Rotherham area at the last-mentioned date was 25.9.

MR. W. C. BRIDGEMAN, Secretary for Mines, has appointed the following to be additional members of the Advisory Committee for the Metalliferous Mining Industry: Mr. William Walter Casson, as a representative of owners of iron ore mines and quarries; Mr. Henry Nixon, as a representative of workers in or about iron-ore mines and quarries.

THE DETAILS of the launches at Sunderland for the past month are as follows: Osbourne, Graham & Company, "Papelera," 1,845 gross tonnage; R. Thompson & Sons, "No. 314," 3,707; S. P. Austin & Son, "Corsea," 2,780; J. L. Thompson & Sons, "York City," 400; Laing & Sons, "British Judge," 875; Pickersgill & Sons, "Aurillac," 4,740.

MR. STANLEY BALDWIN has informed Mr. George Barker that the Board of Trade returns, which it is proposed shortly to issue quarterly instead of monthly, are those relating to the trade of foreign countries and British Possessions. There is no intention of converting the returns relating to the trade of the United Kingdom from a monthly to a quarterly publication.

THE RAND WATER BOARD invites tenders for the supply and delivery at Vereeniging Main Pumping Station of 12 steel trusses for 49 ft. clear span, 12 steel trusses for 42 ft. 6 in. clear span, together with all steel purlins, louvre lanterns, etc. Particulars on application at the Department of Overseas Trade (Room 50a), 35, Old Queen Street, Westminster, S.W.1.

NOTIFICATION HAS BEEN ISSUED at Portsmouth that all men in the Admiralty industrial establishments in receipt of the 12½ per cent. bonus on time earnings or 7½ per cent. bonus on piece rates granted during the war will now lose these extras in accordance with the agreement come to on the subject between the engineering trade unions and the Shipbuilding Employers' Federation.

A MUSICAL EVENING AND EXHIBITION in connection with the Sheffield Association of Metallurgists and Metallurgical Chemists were held at the Royal Victoria Hotel, Sheffield, last week. To those interested in metallurgy the exhibition was most instructive. A special show was made of non-ferrous and ferrous metals, and the various uses to which stainless steel could be put other than for table knives.

AT A CONFERENCE between Mersey Ship Repairers' Federation and Employers' Association, Port of Liverpool, with the Boiler Makers' and Iron and Steel Shipbuilders' Society, on October 28, the question of a national reduction was fully discussed. The men proposed to spread the reduction over six months instead of three, and would, if this suggestion be accepted, promise to persuade their members to accept.

LICENCES HAVE BEEN GRANTED under the Non-Ferrous Metal Industry Act, 1918, to Alexanders Produce Company, Limited, 44/46, Leadenhall Street, London, E.C.3; Channel Shipbreaking Company, Limited, Old Quay, Teignmouth; Electrolytic Zinc Company of Australasia Limited, Pinners Hall, Austin Friars, London, E.C.2.; Milner, G. F., Newgate Street, Chester; and Wilson, J. D., trading as the Don Casting Company, 80, Moland Street, Birmingham.

SHIP REPAIRERS and employés at Cardiff are reported to be greatly disappointed at the failure to secure the contract for the repairs to the Cardiff-owned steamer "Wimborne," recently in collision. In order to keep the job, amounting to thousands of pounds, the men made wage concessions, and the repairers quoted the bare cost. The vessel goes to the North-East Cost, however, the Middle Dock on the Tyne having put in a tender considerably below the lowest Welsh one.

IT IS REPORTED that at a recent wages conference in London shipbuilding employers made a novel offer to trade unions, which the latter declined. It appears that £80,000 has already been spent on a vessel now building on the Tyne, and that about £50,000 is required to complete her. Operations on the vessel are at present suspended, but the employers offered to finish the work at a loss if the trade unions would purchase her for trading. The offer was not accepted.

A PROPOSAL to inaugurate a Scientific Industries Club in Newcastle was referred to at the opening meeting of the session of the North-Eastern Centre of the Institution of Electrical Engineers at the Armstrong College last week. Professor W. M. Thornton, the new chairman, said a proposal was on foot to start a Scientific Industries Club in Newcastle. This already had been made a working proposition by the Society of Chemical Industry, and it was desired to extend the scheme to include all other branches of mechanical practices—mechanical engineering, electrical engineering, etc.

IN ORDER TO ASCERTAIN if their members were agreeable to the proposal made by the National Light Castings Ironfounders' Federation to withdraw the bonuses of 12½ per cent. and 7½ per cent. awarded by the Ministry of Munitions to daysmen and pieceworkers respectively, the Joint Committee of Light Metal Trades Unions have taken a ballot which has resulted in a large majority declaring in favour of accepting the proposed reductions. The figures as announced by the Central Ironmoulders' Association were: For acceptance, 3,835; against, 2,186; majority for acceptance, 1,649.

THE Department of Overseas Trade report that the Municipal Council of Johannesburg are inviting tenders for the supply and delivery of 500 brass bibcocks (½ in., ¾ in.), and 1,775 brass stopcocks (½ in., ¾ in., and 1½ ins.), which must be equal in quality to samples which can be seen at the Johannesburg Municipal Office, and must be tested and stamped by the Municipal Assizer. They must be capable of standing a pressure of 300 lbs. per sq. inch. Assizing fees to be paid by the contractor. Tenders will be received in Johannesburg up to noon on January 25, 1922. A copy of the specification and conditions of tender can be inspected on application at the Department of Overseas Trade (Room 50A), 35, Old Queen Street, London, S.W.1.

Forthcoming Events.

Institution of British Foundrymen.

Coventry Branch.—"Gas in the Foundry," by A. Docking on November 16.

Sheffield Branch.—"The Production of Steel Castings," by F. Darley, on November 18.

Falkirk Section.—"Practical Economies in the Foundry," by R. Clark, J.P., on November 19.

Manchester Association of Engineers.

"The Flow of Metal during Forging," by Harold F. Massey, B.Sc., on November 12.

Discussion on "Foundry Costs and Establishment Charges," introduced by D. Adamson, M.I.Mech.E., on November 25.

Birmingham Metallurgical Society.

Birmingham Branch.—"Recent Progress in the Study of Corrosion," by J Newton Friend, P.H.D., on November 24.

XUM

Company News.

Electric Welding Company, Limited. — Adverse balance, £46,564.

Meters, Limited.—Interim ordinary dividend, 5 per cent. per annum.

Parkgate Iron & Steel Company, Limited.—No interim dividend declared.

Stanton Ironworks Company, Limited.—Interim dividend, 4 per cent., free of tax.

Andrew Knowles & Sons, Limited.—Interim ordinary dividend, 2 per cent., actual, less tax.

South Durham Steel & Iron Company, Limited. — Ordinary dividend, 10 per cent. for year.

Yates & Thom, Limited.—Ordinary dividend, 5 per cent., less tax; reserve, £10,000; carried forward, £15,084.

British Mannesmann Tube Company, Limited.—Interim ordinary dividend, 4 per cent., free of tax; no final dividend anticipated.

Adept Engineering Company, Limited. — Capital £1,000 in £1 shares. Registered office: 180, Green Lanes, Small Heath, Birmingham.

Nantyglo and Blaina Ironworks Company, Limited.—Dividend, £2 per share on account of arrears on 8 per cent. cumulative preference shares, making £5 per share for year.

William Birch (Engineers), Limited.—Capital £12,000 in £1 shares. Directors: V. S. Wood, H. C. Whittle, and H. Coates. Registered office: Milton Street Iron Works, off Bury New Road, Manchester.

Personal.

THE LATE COMMODORE G. W. VIVIAN, a director of Vivian & Sons, Limited, left £8,349.

THE LATE MR. J. COLE, of Messrs. W. and J. Cole, Hope Foundry, Bolton, left £157,254, net personalty £152,636.

COL. G. E. STANLEY-SMITH has been elected a director of Nobel Industries, Limited, in place of the late Sir George Smith.

THE LATE MR. G. HAWKINS, governing director of John W. Harker & Company, Limited, Billiter Street, E.C., left £41,877 gross, with net personalty £34,286.

THE LATE MR. S. H. PATESHALL, London manager of Agricultural and General Engineers, Limited, left estate of the gross value of £18,472.

LORD ASKWITH has been re-elected president of the British Federation of Iron, Steel, Tinplate and Metal Merchants. Sir Chris. T. Needham, Sir John Wallace, J.P., Mr. W. H. Kidston and Mr. J. Gray Buchanan have been elected vice-presidents.

THE LATE MR. A. S. HILL, chairman, managing director and founder of the Coventry Chain Company, Limited, and chairman of Thomas Smith's Stamping Works, Limited, left estate of the gross value of £76,964, with net personalty £65,403.

MR. MYLES KENNEDY, J.P., Stone Cross, Ulverston, has been entertained to dinner at Seascale by the members of the West Coast Hematite Iron Ore Proprietors' Association, on the occasion of his retiral from the position of chairman of the Association. Mr. J. W. Pattinson has succeeded Mr. Kennedy.

MR. ERIC POTTER, Patent Agent and Consulting Engineer, informs us that in consequence of rapid development of the business this is to be reorganised, and in future the consulting and supervising engineering work will be conducted under the style of Messrs. E. Potter & Co. The activities of the firm will be concentrated upon factory architecture, installation of plant and maintenance as previously, and new offices are shortly to be opened at Commerce Chambers, Parliament Street, Nottingham.

New Pneumatic Tools.—Two useful pneumatic tools for speeding up production have recently been added to the list of "Little David" tools manufactured by the Ingersoll-Rand Company, Limited, 165, Queen Victoria Street, London, E.C.4. One is an air-driven wire brush for metal cleaning, which offers an opportunity for considerable saving of time and labour over that required by hand in removing paint, rust, scale and dirt. The wire brush is of very rugged design, and can be used with the standard No. 6 "Little David" drills. The brush has a face-diameter of 5 ins., and is made up of wires of a special heat-treated steel. The whole outfit weighs only 11½ lbs., and runs at 2,000 r.p.m. The other new tool is a pneumatic hammer scoop, and is designed to cut down the cost of loosening stiff clay, hard pan, and fine gravel in such excavations where steam shovels and trenching machines cannot be used. The hammer is of the long-stroke type, fitted with a special handle. The scoop is held in place by a safety retainer.

Gazette.

THE SMETHWICK FOUNDRY COMPANY, LIMITED, are being wound up voluntarily, with Mr. R. T. Hall, 109, Colmore Row, Birmingham, as liquidator.

THAMES TOOL COMPANY, LIMITED, London, E.C.—It was resolved, October 15: That the company be wound up. Mr. J. G. Godwin, 195, Strand, W.C., C.A., has been appointed liquidator.

A. T. SPEEDOMETER COMPANY, LIMITED, London, W., ironfounders, engineers, etc., in liquidation, Mr. F. Rowley, 34/36, Gresham Street, E.C., C.A., was appointed receiver, October 19.

TRADING UNDER THE STYLE of the B.L.A. Engineering Company, Messrs. H. Bolley and R. W. Leeson, 28, Lower Bond Street, Hinckley, engineers, have dissolved partnership. October 15. Mr. R. W. Leeson continues the business.

TRADING UNDER THE STYLE of the Newcastle-upon-Tyne Welding Company, Messrs. A. P. Atkinson, T. R. Gale, and E. A. Campbell, 2 and 4, Back Stephen Street, Bridge-end, Byker, Newcastle-on-Tyne, welding engineers, have dissolved partnership. Debts by T. R. Gale and E. A. Campbell, who continue the business.

FAILURE TO OBTAIN DELIVERY of material purchased, and in consequence his inability to supply a customer with such material, which resulted in a claim for £270 damages, are the causes of failure attributed by A. J. Parker, of 38, Church Street, Sheffield. The total liabilities are £378, and the deficiency is estimated at £307. The debtor commenced business as a scrap and steel merchant at Sheffield in October, 1919, without capital. He was previously connected as director and secretary with the Eureka Ball Bearings Company, Limited, of Church Street, Sheffield.

THE ADJOURNED first meeting of the creditors of G. Sharpe, of 6, Wensleydale Terrace, Gateshead, iron merchant, trading at Midland Chambers, Westgate Road, Newcastle, was held at the Official Receiver's office, Newcastle. The Official Receiver stated that eight proofs had been lodged, amounting to £31,123. Debtor, who stated that he was not insolvent, attributed his failure to being unable to collect money due to him. An application will be made to the Court for debtor to be adjudged bankrupt, and the adjourned public examination is fixed for to-day, November 10.

Deaths.

MR. A. OGDEN, who recently retired from the firm of Ogden & Lawson, brass founders, Barrow and Workington, has since died, aged 79 years.

MR. GAVIN WILSON died at St. Ronans, Corrour Road, Newlands, on October 27. The deceased was associated with the Rivet, Bolt and Nut Company, Limited.

MR. R. ARDILL, of Belfast, a director of Fairbairn, Lawson, Coombe, Barbour, Limited, was drowned through a boating accident in Strangford Lough, Co. Down, on October 20. Mr. Ardill, who was 62 years of age, was a native of Leeds, and as an excellent linguist had travelled practically all over the world in connection with the firm's business. He was elected a director in 1907.

Pre-heated Air v. Direct-Fired Furnace.—Mr. O. Lellep, in the "American Gas Journal," records the results of much experimental work to decide whether it pays to pre-heat air for town-gas-fired furnaces. The saving of fuel due to pre-heated air depends largely on the working temperature of the furnace, and is almost proportional to the temperature of pre-heat. Generally it does not pay to use pre-heated air for town-gas in furnaces working below 1,800 deg. Fah.—particularly with furnaces having an average gas consumption below (say) 500 cub. ft. per hour. Air pre-heating is more justified for high-temperature furnaces working at 2,000 deg. Fah. or more, provided the waste gases can be directed into the heat-exchange system, and the furnace is consuming over 500 cub. ft. per hour. Cast iron recuperators have a short life, if used above red-heat, and therefore cannot be used efficiently at higher temperatures, where the air pre-heating is most advantageous. In a furnace at 2,600 deg. Fah., a reversible regenerating chequer-work air pre-heater may result in twice as much fuel saving as a cast-iron one. The claims raised in connection with air pre-heating are often misleading. Before introducing a system which means complication of the equipment, and extra expense for upkeep, one should be sure that a modern direct-fired furnace is less economical. Surveying the field of possible application, Mr. Lellep thinks it appears safe to say that in most cases air pre-heating does not pay for industrial town-gas furnaces, though there are some few attractive prospects as exceptions to the general rule.

IRON AND STEEL MARKETS.

Pig-iron.

The substantial all-round reduction in quotations for Cleveland pig, as briefly announced in last week's journal, has not, so far, led to any extensive expansion of business, but a perceptible improvement in tone is already to be noted, although buying is still on a quiet scale. In explanation of this attitude on the part of consumers it should be explained that it is reasonably feasible some further reduction in pig-iron prices is possible, when fuel values are finally adjusted on a still lower basis. With regard to Continental competition, French and Belgian pig-iron prices are hardening simply because foreign makers have tired of selling at a loss and the German Pig-Iron Syndicate, faced with an alarming depreciation of the mark, a rise in the price of coke, and a 30 per cent. addition to railway rates, have made an unprecedented advance in prices. In the case of hematite the advance amounts to 890 marks, whilst all foundry grades are 640 marks dearer. Exports from Tees-side ports of pig-iron for October reached 16,959 tons, of which 5,926 went to foreign ports, and 11,033 coastwise. The chief foreign customers were Italy with 2,250 tons, Belgium with 1,647, and Denmark 450. Meanwhile the recent reductions will probably increase the demand for all foundry and forge qualities. The current prices are No. 1 Cleveland foundry iron 115s., No. 3 Cleveland G.M.B. 110s., No. 4 foundry 105s., No. 4 forge 100s., mottled and white about 97s. 6d.

East Coast hematite is still a slow trade, and competition for orders is keen. But here also the outlook is a little brighter. Makers quote 120s. for mixed numbers, and 122s. 6d. for No. 1, but in most cases are prepared to make concessions rather than lose an order. West Cumberland hematite makers still quote £6 8s. 6d. for Bessemer mixed numbers, but have reduced the price of .30 low phosphorus iron by 5s. per ton.

Scrap.

Conditions in the various scrap markets are certainly varied, business in some centres showing symptoms of revival, while others remain quiet and without change. In the latter category may be included the Cleveland market, where demand continues inactive, the few transactions noted being the sale of a few parcels of heavy wrought-iron piling scrap, which only realised 57s. 6d. per ton, delivered. There has also been a little business passing in steel turnings and cast-iron borings, which made up to 40s. per ton delivered works. In the Midlands the recent appreciation reported in the iron and steel scrap market has been maintained, but there has been no fresh advance, although it is expected that before long steel scrap will be realising 5s. or 10s. per ton more than it is at the present moment. Dealers have no difficulty at the present moment in selling heavy steel scrap at the figures mentioned last week—£2 10s. to £2 15s. per ton, f.o.r., according to quality. Steel turnings are still firm at 30s. to 32s. 6d. per ton, f.o.r. local stations, and cast-iron borings at £1 7s. 6d. There is not a great demand for wrought-iron piling scrap, but where sales are taking place this is fetching £3 15s. to £4 5s., delivered works, and £3 for balling iron. There is also no great demand for cast-iron scrap for foundry purposes, but a few sales are taking place at the prices quoted last week.

Finished Iron.

In common with other sections of the trade, business in finished iron shows little change in the general conditions, although the recent reductions in prices have certainly imparted a more cheerful view to the outlook. There can be little question now that demand is slowly recovering, stimulated to a large extent by the more reasonable attitude of sellers, and with further substantial reductions in costs of raw materials, labour and transport charges in immediate prospect markets are steadily regaining some degree of confidence. The position in finished iron has also been favourably influenced by the recent settlement of the bonus question in the engineering branches, and will have a considerable effect upon the foundry industry, which for some time has been more or less in an idle condition. Makers of marked bars continue fairly well employed, but mills turning out crown and the ordinary qualities of this material still complain of scanty order books. South Staffordshire ironmasters claim that they require much cheaper fuel and pig-iron before they can carry on satisfactorily and bid for new business with vigour, but they are moving in the right direction. Quotations are unchanged as follow:—Marked bars, £17 10s. (net, f.o.t. makers' works); crown bars, £14 10s.; gas strip, £15 (both net, delivered Birmingham).

Steel.

Although without any tangible change in the general position, business in steel and its various products can hardly be described as exactly stagnant, some branches being still employed to a partial extent, while a more hopeful outlook is entertained of a revival of activity after the turn of the year. For the present, however, the business doing continues limited in scope, the overseas market being the weak spot in the situation, while home-buying is also restricted to merely immediate requirements. Some encouragement for consumers should, however, be derived from the steady downward trend of steel prices, amongst the latest developments in this direction being last week's decision of the South Wales Siemens Steel Association, who, in order to encourage the tinplate and galvanised sheet industries, further reduced the price of bars from £8 5s. to £7 15s. per ton. At Sheffield, acid billets have also been reduced a further £1 per ton, and Siemens' quality is now quoted at £13, and Bessemer at £12 10s. Basic material was reduced the previous week. No increase of business has yet followed the concessions, but it is expected to help matters later. In the Tees-side steel trade there is undoubtedly a determination to shoulder heavy losses in order to get the industry going again. Once prices reach rock bottom it is believed that big orders will be placed, and it is only by mass production that makers can hope to make ends meet. Meanwhile there is a little more movement, and many firms whose plant is idle are closely watching the trend of events.

Tinplates.

Conditions in the tinplate market may be reported as fairly steady, a slightly better volume of inquiries coming to hand, from which a fair proportion of orders has materialised. The prices paid range round 21s. 3d. to 21s. 6d. basis for coke tins, net cash, f.o.b., for December/January. Prompt plates are in most demand, and these are realising from 22s. and upwards per box basis in cokes, charcoals running from 2s. 6d. to 5s. basis extra for ordinary grade. Wasters are in demand for the home trade, C.W. 28 x 20 realising 40s. per box; C.W. 14 x 20, 19s. 9d. to 20s. per box; and C.W. 14 x 18¾, 16s. 6d. to 16s. 9d. per box, all net f.o.t. at works. Terneplates are meeting with a little more inquiry, mainly for export, transactions being reported on a basis of 21s. for usual specifications, f.o.b.

Metals.

Copper.—The market for standard copper, influenced by week-end American advices, opened with a quiet tendency, with sales for three months done at £66 10s. Refined metal was also a quiet market, electrolytic advancing, closing at £73 10s. to £75 10s. Closing prices.—Cash: Wednesday, £67; Thursday, £66 15s.; Friday, £66 15s.; Monday, £65 17s. 6d.; Tuesday, £66 5s. Three Months: Wednesday, £67 7s. 6d.; Thursday, £67 5s.; Friday, £67 2s. 6d.; Monday, £66 10s.; Tuesday, £66 15s.

Tin.—The opening market of the week, as concerns this metal, developed some features of interest, a week-end cablegram from the East showing a rise of 20s., being followed by active buying by Dutch interests, and although only an average turnover was recorded, the tone throughout was fairly steady. English ingots were advanced 40s. at £158. Closing prices.—Cash: Wednesday, £155; Thursday, £155 5s.; Friday, £156 15s.; Monday, £158 10s.; Tuesday, £158 10s. Three Months: Wednesday, £158 5s.; Thursday, £157 10s.; Friday, £168 10s.; Monday, £160; Tuesday, £160 10s.

Spelter.—Business in this metal continues quiet, the week's markets opening with holders maintaining a reserve attitude, values closing without change. Closing prices.—Wednesday, £26 2s. 6d.; Thursday, £26 2s. 6d.; Friday, £26 2s. 6d.; Monday, £26 2s. 6d.; Tuesday, £26 2s. 6d.

Lead.—The market for soft foreign pig opened with a steady tone, with November sold £23 15s.; December, £23 10s.; January, £23 10s.; and February, £23 15s. English closing prices.—Wednesday, £24 15s.; Thursday, £24 15s.; Friday, £24 15s.; Monday, £24 15s.; Tuesday, £24 15s.

XUM

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d
Standard cash	66	5	0
Three months	66	15	0
Electrolytic	74	0	0
Tough	66	10	0
Best selected	66	15	0
Sheets	101	0	0
India	94	0	0
Wire bars	75	5	0
Do. Nov.	75	5	0
Do. Dec.	75	5	0
Ingot bars	75	5	0
H.C. wire rods	80	15	0
Off. aver. cash, Oct.	67	8	1½
Do. 3 mths., Oct.	68	8	11½
Do. Settlement Oct.	67	7	10½
Do. Electro, Oct.	74	9	9½
Do. B.S., Oct.	68	16	10½
Aver. spot, copper, Oct.	67	6	10½
Do. Electro, Oct.	75	10	0

Solid drawn tubes .. 14½d.
Brazed tubes .. .. 14½d.
Wire .. .. .. 11d.
Yellow metal rods .. 7½d.
Do. 4x4 Squares .. 9d.
Do. 4x3 Sheets .. 9d

BRASS.

Solid drawn tubes .. 12½d.
Brazed tubes 15½d
Rods .. .. .. 11½d.
Sheets to 10 w.g. .. 11½d.
Wire .. .. .. 11½d.
Rolled metal .. 10½d.

TIN.

Standard cash	158	10	0
Three Months	160	10	0
English	157	10	0
Bars	159	10	0
Chinese	156	0	0
Straits	159	0	0
Australian	159	0	0
Eastern	159	10	0
Banca	159	0	0
Off. aver., cash Oct.	156	10	0
Do. 3 mths., Oct.	158	15	7½
Do. Sttlment., Oct.	156	9	3½
Aver. spot, Oct	156	7	6

SPELTER.

Ordinary	26	2	6
Remelted	23	10	0
Hard	17	5	0
Electro 99.9	32	10	0
English	nominal		
India	20	15	0
Prime Western	27	2	6
Zinc dust	45	0	0
Zinc ashes	5	0	0
Off. aver., Oct.	26	10	6½
Aver., spot, Oct.	26	6	3½

LEAD.

Soft foreign ppt	24	0	0
English	24	15	0
Off. average, Oct.	23	10	8½
Average spot, Oct.	23	13	7

ZINC SHEETS.

Zinc sheets, spot	35	10	0
Do. V.M. ex whf.	35	0	0
Do. ppt., f.o.b., N.Y.	—		
Dutch	34	0	0
Boiler plates	32	10	0
Battery plates	32	0	0

ANTIMONY.

English regulus	36	10	0
Special brands	38	0	0
Chinese	24	10	0
Crude	17	0	0

QUICKSILVER.

Quicksilver 10 0 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—
45/50% 12 5 0
75% 20 0 0

Ferro-vanadium—
35/40% .. 20/6 lb. va.

Ferro-molybdenum—
70/80% .. 6/6 lb. mo.

Ferro-titanium—
23/25%, carbonless 1/3 lb.

Ferro phosphorus, 20/23%, £23

Ferro-tungsten—
80/85%, carbon free 1/5½ lb.

Tungsten metal powder—
98/99% .. .. 1/8 lb.

Ferro-chrome—
4/6% car. £27 10
6/8% car. £26 10
8/10% car. .. £25 10

Ferro-chrome—
Max. 2% car. .. £78
Max. 1% car. .. £93
Max. 0.75% car. .. £110
66 70%, carbonless 2/3 lb.

Nickel—99·8%, cubes or pellets .. £190

Cobalt metal—97%.. 14/- lb.

Aluminium—98/99% £115

Metallic Chromium—
98/99% .. .. 5/6 lb.

Ferro-manganese—
76/80%, loose .. £15
76/80%, packed .. £16
76/80%, export .. £14 10

Metallic manganese—
98/99%, carbonless 2/7 lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten .. .. s. d. 2 8

Finished bars, 18% tungsten 3 3

Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ¾ in. to ¼ in. by ¼ in., and all sizes over four times in width over thickness .. .. 3d. lb.
Bevels of approved sizes and sections .. 6d. lb.
If in coils .. .. 3d. lb.
Packing .. .. 5s. cwt
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces .. .. 5d.
Turnings and swarf .. 2d.

Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—	£	s.	d.
Heavy Steel	3	2	6
Bundled steel & shearings	2	15	0
Mixed iron & steel	2	12	6
Heavy cast iron	3	12	0
Good machinery for foundries	5	10	0

Cleveland—			
Heavy steel	2	15	0
Steel turnings	2	0	0
Cast-iron borings	2	0	0
Heavy wrought iron piling	2	17	6
Bundling scrap	3	0	0
Cast-iron scrap	4	10	0

Lancashire—			
Cast iron scrap	5	2	6
Heavy wrought	3	10	0
Steel turnings	2	5	0

London—	£	s.	d.
Copper (clean)	50	0	0
Brass (clean)	27	0	0
Lead (less usual draft)	18	0	0
Tea lead	16	0	0
Zinc	13	0	0
New aluminium cuttings	50	0	0
Braziery copper	40	0	0
Gun metal	38	0	0
Hollow pewter	115	0	0
Shaped black pewter	65	0	0

PIG-IRON.

(Premiums required for foundry).

N. E. Coast—
Foundry No. 1 .. 115/-
Foundry No. 3 .. 110/-
Forge No. 4 .. .. 100/-
Mottled 97/6
Hematite No. 1 .. 122/6
Hematite M/Nos. .. 120/-

Midlands—
Staffs. common .. 145/-
„ part-mine forge 160/-
„ „ foundry 180/-
„ Cold blast .. —
„ basic .. .. —

Northants forge .. 95/-
„ foundry No. 3 105/-
„ basic .. .. —

Derbyshire forge .. 100/-
„ foundry No. 3 110/-
„ basic .. —

Scotland—
Foundry No. 1 .. 140/-
„ No. 3 .. 135/-
Hematite M/Nos. .. 142/6

Sheffield (d/d district)—
Derby forge .. .. —
„ foundry No. 3 —
„ basic .. .. —
Lincs. forge .. .. —
„ foundry No. 3 —
„ basic .. .. —
E.C. hematite .. 133/-
W.C. hematite .. 145/-
All d/d in the district.

Lancashire (d/d eq. Man.) —
Derby forge .. .. —
„ foundry No. 3 —
Northants foundry No. 3 .. .. —
Cleveland foundry No. 3 .. .. —
Staffs. foundry No. 3 —
Lincs. forge .. .. —
„ foundry No. 3 —
Summerlee foundry .. 163/9
Glengarnock foundry 163/-
Gartsherrie foundry 163/-
Monkland foundry .. 160/-

FINISHED IRON & STEEL.

Iron—	£	s.	d.
Bars (crown)	14	0	0
Angles	14	10	0
Tees to 3 united ins.	15	0	0
Nut and bolt	14	10	0
Hoops	17	5	0
Marked bars (Staffs.)	17	10	0
Gas strip	15	0	0
Bolts and nuts, ¾ in. × 4 in.	26	0	0

Steel—			
Ship plates	10	10	0
Boiler plates	16	0	0
Chequer plates	11	10	0
Angles	10	0	0
Tees	11	0	0
Channels	10	5	0
Joists	10	10	0
Rounds, ¾ in.–3-in.	12	0	0
Rounds, 3 in.–5½ in.	11	10	0
Flats, 5 in.–8 in.	13	0	0
Flats over 8 in.	13	0	0
Rails, heavy	10	10	0
Fishplates	17	10	0
Hoops	13	10	0
Black sheets, 24 g.	15	0	0
Galv. cor. sheets, 24 g.	18	10	0
Galv. fencing wire, 8 g. plain	17	10	0
Rivets, ¾ in. dia	20	0	0
Billets, soft	7	5	0
Billets, hard	8	5	0
Sheet and tin bars	7	15	0

PHOSPHOR BRONZE.

	Per lb basis.
Strip	1 5½
Sheet	1 6½
Wire	1 5½
Rods	1 5
Tubes	1 7½
Castings	1 2½

Delivery 3 cwt. free to any town.
10% phosphor copper, £40 above price of B.S.
15% phosphor copper, £50 above price of B.S.
Phosphor tin (5%), £30 above price of English ingots.
CHARLES CLIFFORD & SON, LIMITED, BIRMINGHAM.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	1/- to 1/6
Rolled—	
To 9 in. wide	1/7 to 2/1
To 12 in. wide	1/7½ to 2/1½
To 15 in. wide	1/8½ to 2/2½
To 18 in. wide	1/9½ to 2/3½
To 21 in. wide	1/10½ to 2/4½
To 24 in. wide	1/11½ to 2/5½
Ingots for spoons and forks	1/- to 1/6
Ingots rolled to spoon size	1/3 to 1/9
Wire round—	
3/0 to 10. G.	1/9½ to 2/4½

with extras according to gauge

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	28.84
No. 2 foundry Valley	21.00
No. 2 foundry, Birm.	19.00
Basic	20.96
Bessemer	21.96
Malleable	22.46
Grey forge	21.96
Ferro-manganese 80 % delivered	60.00
Bess. rails, h'y, at mill	40.00
O.-h. rails, h'y, at mill	40.00
Bess. billets	29.00
O.-h. billets	29.00
O.-h. sheet bars	30.00
Wire rods	40.00
	Cents.
Iron bars, Phila.	1.95
Steel bars	1.50
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.65
Skelp, sheared steel	1.65
Steel hoops	2.25
Sheets, black, No. 28	3.00
Sheets, galv., No. 28	4.00
Sheets, blue an'l'd, 9&10	2.25
Wire nails	2.90
Plain wire	2.60
Barbed wire, galv.	3.55
Tinplate, 100-lb. box	$5.00

COKE.

Welsh foundry .. 50/- 55/-
„ furnace .. 25 - 30/-
Durham & North. foundry 53/-
„ furnace 35/-
Other Districts, foundry 60/-
„ furnace 23/-